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The purpose of this manual is to provide the On-Scene Coordinator (OSC) with a systematic methodology consistent with national policy that can be used to assess the case-by-case acceptability of oil spill treatment using chemicals, and to determine appropriate application procedures.

It contains guidelines for evaluating spill safety, determination of relevant spill characteristics, prediction of treated and non-treated spill movement, and criteria for comparison of probable impacts with and without treatment. Dispersion of oil at sea, dispersion on the shoreline, and the use of surface collecting agents are considered. The manual additionally describes general chemical agent application procedures and dosage regulation.

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CHEMICAL TREATING AGENTS IN OIL SPILL CONTROL

by

Robert W. Castle, Carl R. Foget, and Eric Schrier
Woodward-Clyde Consultants
Three Embarcadero Center, Suite 700
San Francisco, California 94111

Contract No. 68-03-2621

Project Officer

Leo T. McCarthy, Jr.
Solid and Hazardous Waste Research Division
Oil and Hazardous Materials Spill Branch
Municipal Environmental Research Laboratory (Cincinnati)
Edison, New Jersey 08837

MUNICIPAL ENVIRONMENTAL RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OHIO 45268

DISCLAIMER

This report has been reviewed by the Municipal Environmental Research Laboratory - Cincinnati, U.S. Environmental Protection Agency, and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the U.S. Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

FOREWORD

The U.S. Environmental Protection Agency was created because of increasing public and government concern about the dangers of pollution to the health and welfare of the American people. Noxious air, foul water, and spoiled land are tragic testimonies to the deterioration of our natural environment. The complexity of that environment and the interplay of its components require a concentrated and integrated attack on the problem.

Research and development is that necessary first step in problem solution; it involves defining the problem, measuring its impact, and searching for solutions. The Municipal Environmental Research Laboratory develops new and improved technology and systems to prevent, treat, and manage wastewater and solid and hazardous waste pollutant discharges from municipal and community sources, to preserve and treat public drinking water supplies, and to minimize the adverse economic, social, health, and aesthetic effects of pollution. This publication is one of the products of that research and provides a most vital communications link between the researcher and the user community.

The purpose of this manual is to provide the On-Scene Coordinator (OSC) with a systematic methodology consistent with national policy that can be used to assess the case-by-case acceptability of oil spill treatment using chemicals, and to determine appropriate application procedures.

Francis T. Mayo, Director
Municipal Environmental Research Laboratory

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SECTION 100

INTRODUCTION

101 PURPOSE

The major types of oil spill response actions include physical containment, mechanical recovery, and chemical treatment. Those actions resulting in the actual recovery of the spilled material are preferred. However, such actions are operationally limited to relatively calm conditions, localized areas, and cases where there is minimal risk of fire or explosion. The use of chemical treating agents (dispersants and surface collectors) expands the range of operating conditions under which mitigating actions can be conducted, permits treatment of large areas, and reduces fire and explosion hazard.

This manual of practice is designed to provide a systematic methodology for determining the acceptability of using chemical agents in the treatment of oil spills. The methodology allows assessment of the threat or extent of sensitive area contamination, evaluation of the relative impacts associated with various response alternatives, and selection of appropriate application methods.

102 THE NATIONAL OIL AND HAZARDOUS SUBSTANCES POLLUTION CONTINGENCY PLAN

Developed pursuant to Public Law 92-500 (The Federal Water Pollution Control Act), the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) provides a basis for ensuring efficient, coordinated, and effective action to minimize damage from oil and hazardous substance discharge, including containment, dispersal, and removal. While advocating physical control and removal of spilled oil, the NCP (Part 1510, Chapter V, Title 40, The Code of Federal Regulations) provides a schedule for case-by-case utilization of chemical treating agents and other additives. Known as Annex X, this schedule is reproduced in Appendix A.

Annex X permits case-by-case consideration of chemical dispersion in the following circumstances:

- In any case when, in the judgment of the federal On-Scene Coordinator (OSC), its use will prevent or substantially reduce hazard to human life or limb or substantially reduce explosion or fire hazard to property.
- For major or medium discharges when, in the judgment of the on-scene Environmental Protection Agency representative, its use will prevent or reduce substantial hazard to a major segment of the population(s) of vulnerable species of waterfowl.
- For major and medium discharges when, in the judgment of the Environmental Protection Agency response team member in consultation with appropriate state and federal agencies, its use will result in the least overall environmental damage, or interference with designated water uses.

Annex X also permits case-by-case consideration of surface collecting agent use under the following conditions:

- For all size discharges when its use will result in the least overall environmental damage or interference with designated water uses.
- For all size discharges when its use will provide a key element in the most effective system for removing oil from the water environment.

Annex X requires submission of certain product and laboratory test data prior to consideration of a product for field use. Data so submitted are intended to provide information for case-by-case decision-making by on-scene federal personnel.

The NCP further provides for certain technical, logistical, and scientific support. This manual is designed to incorporate and utilize these provisions and resources. As such, it is essential that the user of this manual be familiar with the provisions, procedures, and restrictions of the NCP in general and Annex X in particular.

103 USE OF MANUAL

This manual provides the user with guidelines which enable case-by-case assessment of the feasibility and acceptability of chemical agent use in the control of oil spills in the marine environment. Figure 103-1 presents a flow diagram illustrating the decision-making sequence and general organization of the manual. Each decision point indicated represents one or more subsections of the manual, which provide instructions on how to conduct a specific evaluation or make a decision.

Section 200 contains field checklists which assemble information necessary to access chemical treatment feasibility and application criteria, and to compare impacts resulting from the available options.

Section 300 uses portions of this material to develop assessments regarding spill characteristics and movement. It also provides criteria to assess fire and explosion hazards. Use of chemical agents is acceptable to the degree necessary to mitigate risk to human life, limb, or property without further qualification.

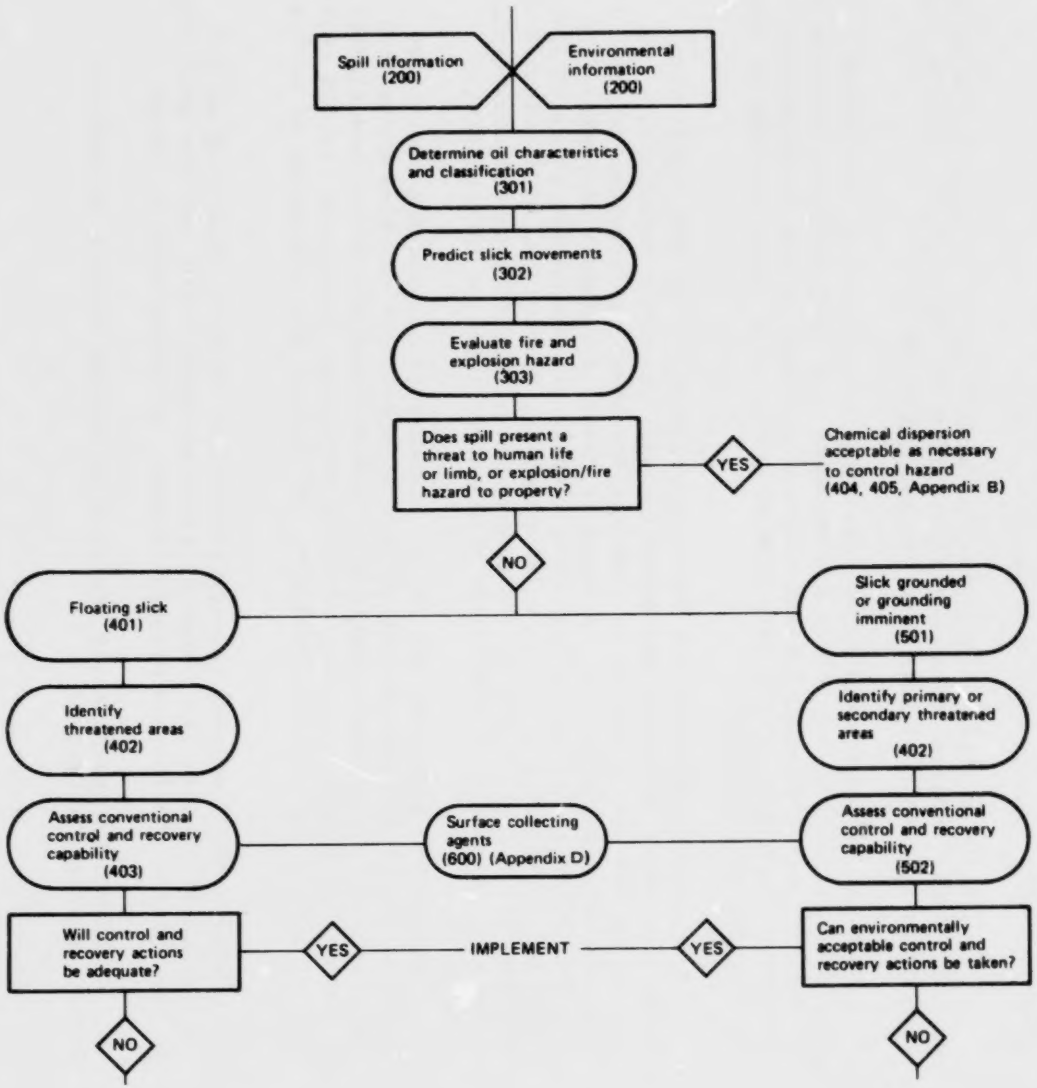
Section 400, Criteria for the Dispersion of Oil at Sea, deals with situations where shoreline contamination will not occur immediately. In evaluating the acceptibility of chemical treatment, it provides criteria for identification of threatened features or areas; assessment of control and recovery potential using conventional techniques; evaluation of oil dispersibility; application techniques, dispersants, and dosage; prediction of oil movement and characteristics; and comparison of the impacts associated with dispersion versus those associated with conventional or no treatment.

Section 500 discusses the use of dispersants in treating shorelines where oiling is imminent or has already occurred. It provides guidelines for assessment of the probable adequacy of conventional protection and cleanup; evaluation of probable natural cleaning processes; guidelines for the selection of agent, application technique, and dosage; and assessment of ecologic factors.

Section 600 discusses the applications of surface collecting agents; environmental factors which control their successful use; and the selection of appropriate application methods, dosage, and supporting equipment.

A series of appendices is included to provide support information. These appendices include:

Appendix A	Annex X
Appendix B	Techniques for Dispersion at Sea
Appendix C	Techniques for Dispersion on Shorelines
Appendix D	Techniques for Use of Surface Collecting Agents


Spill information (200)
Environmental information (200)
Determine oil characteristics and classification (301)
Predict slick movements (302)
Evaluate fire and explosion hazard (303)
Does spill present a threat to human life or limb, or explosion/fire hazard to property?
YES
Chemical dispersion acceptable as necessary to control hazard (404, 405, Appendix B)
NO
Floating slick (401)
Slick grounded or grounding imminent (501)
Identify threatened areas (402)
Identify primary or secondary threatened areas (402)
Assess conventional control and recovery capability (403)
Surface collecting agents (600) (Appendix D)
Assess conventional control and recovery capability (502)
Will control and recovery actions be adequate?
YES
IMPLEMENT
YES
Can environmentally acceptable control and recovery actions be taken?
NO
NO

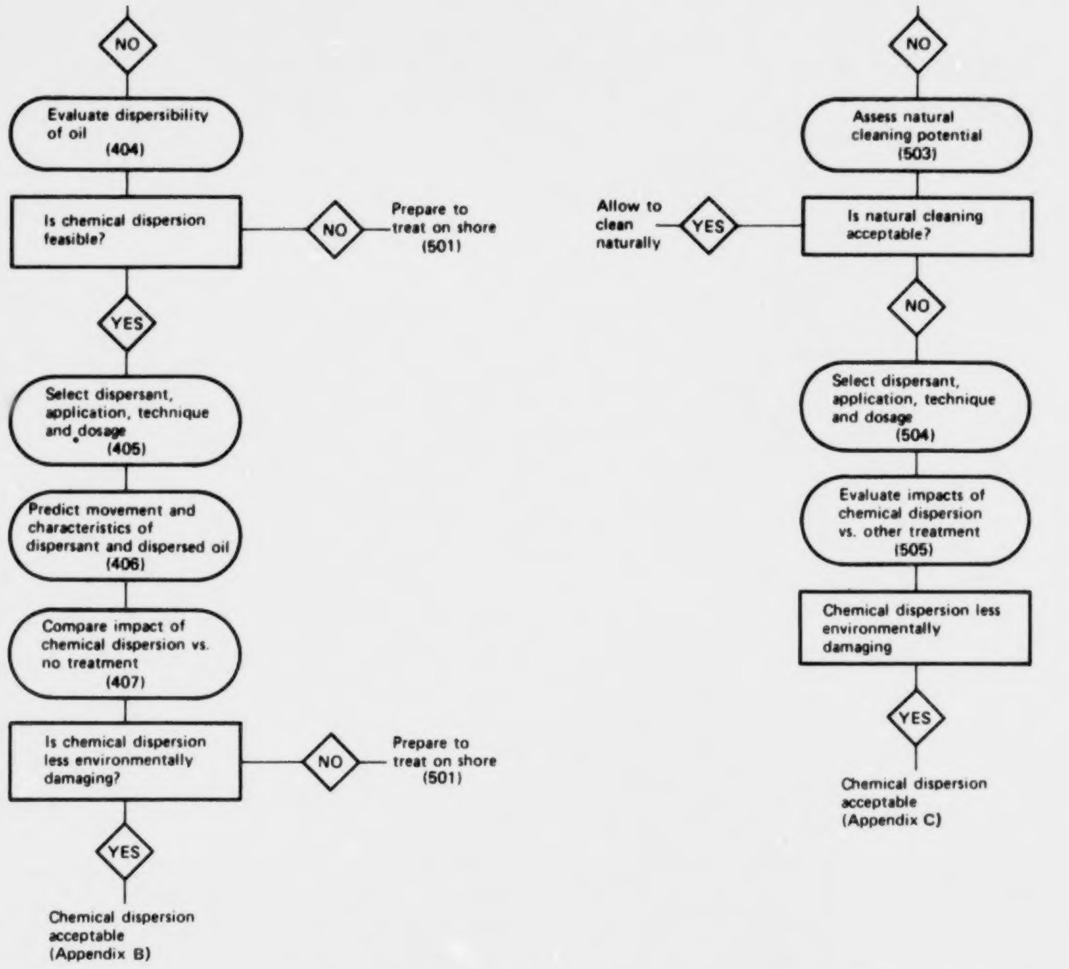

NO
Evaluate dispersibility of oil (404)
Is chemical dispersion feasible?
NO
Prepare to treat on shore (501)
YES
Select dispersant, application, technique and dosage (405)
Predict movement and characteristics of dispersant and dispersed oil (406)
Compare impact of chemical dispersion vs. no treatment (407)
Is chemical dispersion less environmentally damaging?
NO
Prepare to treat on shore (501)
YES
Chemical dispersion acceptable (Appendix B)
NO
Assess natural cleaning potential (503)
Is natural cleaning acceptable?
YES
Allow to clean naturally
NO
Select dispersant, application, technique and dosage (504)
Evaluate impacts of chemical dispersion vs. other treatment (505)
Chemical dispersion less environmentally damaging
YES
Chemical dispersion acceptable (Appendix C)

Figure 103-1. Chemical treatment of oil spills - decision process.

SECTION 200
INFORMATION CHECKLIST

Evaluation of the acceptability of chemical agent use involves numerous assessments requiring a variety of information. While many types of information can be assembled for a geographic area prior to actual need, every spill has its own combination of unique characteristics which can only be determined during the incident. Tables 200-1 and 200-2 are checklists designed to facilitate collection of appropriate data.

Table 200-1 lists general information including time, location, volume, and characteristics of the oil which can be used in estimating the extent of the spill and its treatability. Meteorologic and oceanographic data are also included to help predict spill movement and conventional cleanup potential.

Table 200-2 guides the collection of general ecologic data which are necessary to identify possible threats and evaluation of impacts. Normally, state and local officials and experts are available to contribute this type of information. Their input may be particularly valuable in the identification of local conditions, problems, and attitudes.

TABLE 200-1. GENERAL SPILL INFORMATION

INCIDENT DATA

Apparent source: ____________________

Time and date: ____________________

Location: ____________________

Is spill continuing? Yes __________ No __________

Volume of discharge: Known __________ (barrels)

Estimated __________ (barrels)

Loss rate if continuing: __________ (barrels/day)

Size and location of slick: (plot on chart)

Observed rate and direction of slick movement: __________

Oil type: A ______ B ______ C ______ D ______ (section 301)

Slick type: Continuous ______ Windrows ______ Other (specify) ______

Estimated average thickness: __________

Emulsification: __________

METEOROLOGIC DATA

Air temperature: __________ °C

Wind: Speed __________ Direction __________

Precipitation: __________

Visibility: __________

Forecast: __________

OCEANOGRAPHIC DATA

Water temperature: __________ °C

Currents: Type ______ Speed ______ Direction ______

Sea state: 1 ______ 2 ______ 3 ______ 4 ______ 5 ______ 6+ ______

Average wave height (crest to trough): __________ (m)

HYDROLOGIC DATA (near shore)

Wave height: __________ (m)

Currents:

Tidal (ebb): Velocity ______ Direction ______ Duration ______

Tidal (flood): Velocity ______ Direction ______ Duration ______

Slack water: __________ (min)

Longshore currents: Velocity ______ Direction ______

Tidal range: ______ Rising ______ Falling ______

Turbidity: __________

ADDITIONAL INFORMATION

____

____

TABLE 200-2. ENVIRONMENTAL DATA

OFFSHORE AREAS

Sensitive Marine Resources

Waterfowl: Present ____________ Species ____________ Number ____________
Marine mammals: Present ____________ Species ____________ Number ____________
Other (specify): ____
____

Commercial Use

Industrial (specify type, location): ______________________________
Finfish (specify type, location): ______________________________
Shellfish (specify type, location): ______________________________
Other (specify type, location): ______________________________
Recreational/Navigational use: ______________________________
Other special features: ______________________________
____

NEARSHORE/ONSHORE AREAS

Sensitive Marine Resources

Waterfowl: Present ________ Species ________ Number ________ Nesting Area ________
Marine mammals: Present ____________ Species ____________ Number ____________
Estuaries: ______________________________
Wetlands: ______________________________
Coral reefs: ______________________________
Rare, endangered, unique species/ associations (specify species/type): ______________________________
Other (specify): ______________________________
____

Commercial Use

Industrial (specify) ______________________________
Finfishery: ______________________________
Shellfishery: ______________________________
Other: ______________________________
____

Recreational Use

Harbors: ______________________________
Recreational beaches/parks: ______________________________
Boating: ______________________________
Tourism: ______________________________
Other (specify): ______________________________
____

SECTION 300

SPILL CHARACTERISTICS AND MOVEMENT

301 OIL CLASSIFICATION

Petroleum can differ widely in its physical and chemical properties and reactions when spilled in the environment or subjected to various types of control actions. Weathering, emulsification, and other processes can further alter the nature of the material with time. An understanding of the oil and its probable reactions is necessary in predicting impacts and designing an effective spill response.

The spilled material must be assessed as it reacts and changes in the field. The following field classification groups oils into categories having features common to both physical and chemical treatment. The four classes of oil are:

- CLASS A: Low viscosity, high spreading rate oils
- CLASS B: Moderate or high viscosity, waxy or paraffin-base oils
- CLASS C: High viscosity, low spreading rate, asphaltic or mixed-base oils
- CLASS D: Non-spreading oils.

Table 301-1 summarizes representative oils, diagnostic properties, and physical/chemical characteristics for each class.

Class A: Low Viscosity, High Spreading Rate Oils

This class typically includes light fuel oils and many light crude oils. These materials are generally flammable when fresh. Class A oils can be identified by high fluidity, clarity, rapid spreading rate, strong odor, and high evaporation rate. They do not tend to adhere to surfaces and can usually be removed by flushing. Their tendency to penetrate porous surfaces is high, and when incorporated in reducing substrates, Class A oils may be persistent. When fresh, oils of this class can be considered highly toxic. Class A oils tend to form unstable emulsions. Heavier Class A oils may partially evaporate, leaving a residue that may fall into one of the other response classes.

Class B: Moderate or High Viscosity Waxy Oils

This class includes medium to heavy paraffin-base oils distinguished by a waxy or non-sticky feel. The oils of this class adhere to rock, plant and other surfaces, but tend to be moderately removable by flushing. Their

TABLE 301-1. SPILL RESPONSE OIL CLASSIFICATION

Field-Determined Oil Type	Designation	Representative Oils	Diagnostic Properties	Physical/Chemical Properties
A	Low viscosity, high spreading rate oils	Distillate fuel and light crude oils (all types)	Highly fluid, usually transparent but can be opaque, strong odor, rapid spreading, can be rinsed from surfaces by simple agitation.	May be flammable, high rate of evaporative loss of volatile components, assumed to be highly toxic when fresh, tend to form unstable emulsions, may penetrate substrates, respond well to most control techniques.
B	Moderate or higher viscosity paraffin base oils	Medium to heavy paraffin base refined and crude oils; water-in-oil emulsions	Moderate to high viscosity, waxy feel, can be rinsed from surfaces by low pressure water flushing.	Generally removable from surfaces, soil penetration variable, toxicity variable. Includes water-in-oil emulsions.
C	High viscosity low spreading rate oils	Residual fuel oils; medium to heavy asphaltic and mixed-base crudes; weathered oil	Typically opaque brown or black, sticky or tarry, viscous, cannot be rinsed from surfaces by agitation.	High viscosity, hard to remove from surfaces, tend to form stable emulsions, high specific gravity and potential for sinking after weathering, low substrate penetration low toxicity (biological effects due primarily to smothering). Will interfere with many types of recovery equipment.
D	Nonfluid oils (at ambient temperature)	Residual and heavy crude oils (all types); weathered oil, water-in-oil emulsions	Tarry or waxy lumps.	Nonspreading, cannot be recovered from water surfaces using most conventional cleanup equipment, cannot be pumped without preheating or slurrying, initially relatively nontoxic, may melt and flow when stranded in sun.

tendency to penetrate permeable substrates is variable, and increases as temperatures rise. Toxicity is variable depending on the percentage of volatile components. When weathered or subjected to low temperatures, they commonly become solid and fall into the Class D category. Water-in-oil emulsions (Mousse) which still flow, generally fit into this class.

Class C: High Viscosity, Low Spreading Rate Asphaltic Oils

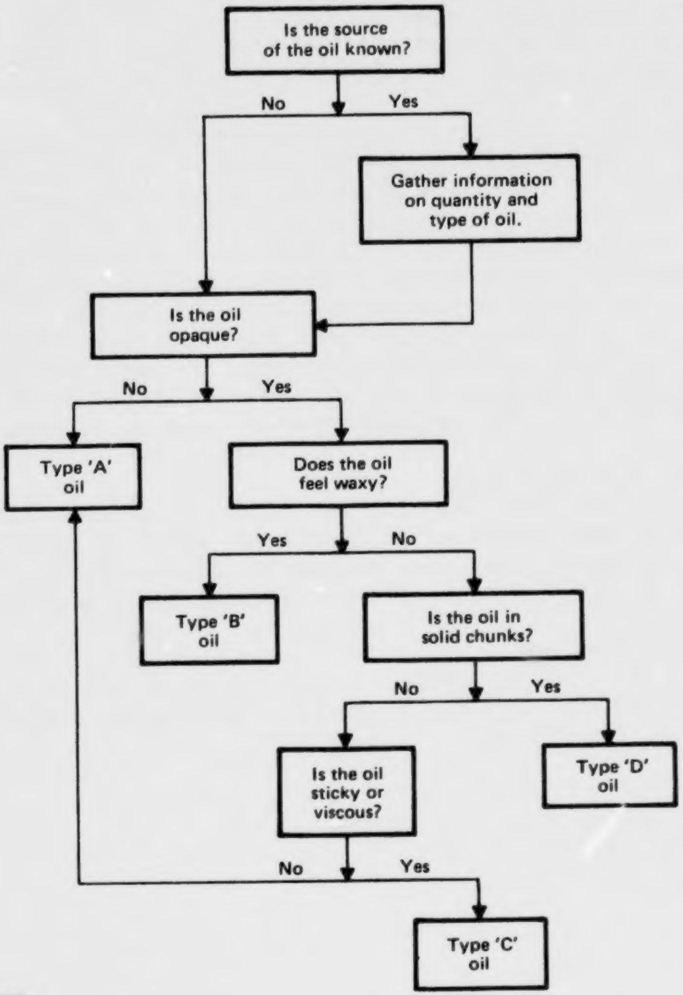
This class normally includes residual fuel oils and heavier asphaltic and mixed-base crude oils which are in the fluid state at ambient temperatures. Characteristically viscous, sticky or tarry, and brown or black in color, they generally adhere to substrates and resist removal by flushing. After natural light ends and cutter stock evaporate, their toxicity tends to be low. Biological effects are generally the result of smothering. The ability to penetrate substrates is typically low. Many Class C oils have a specific gravity near or exceeding that of water and may sink. Class C oils will weather to a tar- or asphalt-like consistency and then may be considered as Class D oils. The emulsions formed tend to be stable.

Class D: Nonfluid Oils

This class includes residual oils, heavy crude oils, some high paraffin crude oils, and weathered oils that are solid or nonfluid at spill temperatures. In solid form, they are essentially nontoxic. Class D oils may react as Class A, B, or C at temperatures above their pour point.

Oil Identification

The criteria for field categorization of oil type are shown graphically in Figure 301-1. The key diagnostic factors are described on the lower left portion of the figure.


Is the source of the oil known?
No
Yes
Gather information on quantity and type of oil.
Is the oil opaque?
No
Yes
Type 'A' oil
Does the oil feel waxy?
Yes
No
Type 'B' oil
Is the oil in solid chunks?
No
Yes
Is the oil sticky or viscous?
Type 'D' oil
No
Yes
Type 'C' oil

DEFINITION OF TERMS

OPAQUE:	Cannot see through coating of oil.
WAXY:	Feels slick but is not sticky, can be easily wiped off fingers or hand with a cloth, can be viscous.
SOLID OR CHUNKY:	Does not flow, can have solid consistency or be soft like putty.
STICKY OR VISCOUS:	Oil is very sticky and has a thick consistency, is not easily removed from hands or fingers without using detergents or solvent.

Figure 301-1. Field identification of oil types.

302 SLICK MOVEMENT

General

Slick movement prediction is necessary to determine the location of potential shoreline and/or sensitive area contamination, and for direction of response actions. Helpful data to predict oil spill movement are (listed in order of importance): 1) surface current speed and direction, 2) wind speed and direction, and 3) oil spreading characteristics. An accurate assessment of spill volume is needed to determine cleanup equipment and chemical treating agent requirements. In addition, an understanding of the slick surface behavior is important in the selection of control techniques and treatment dosages.

Estimation of Spill Volume

Spill volume determines, in part, the amount of equipment, manpower and other resources needed to execute the response. Because early estimates of spill size are often unavailable or of questionable accuracy, first-hand on-site estimations are generally necessary. The following methods can provide rapid working approximations:

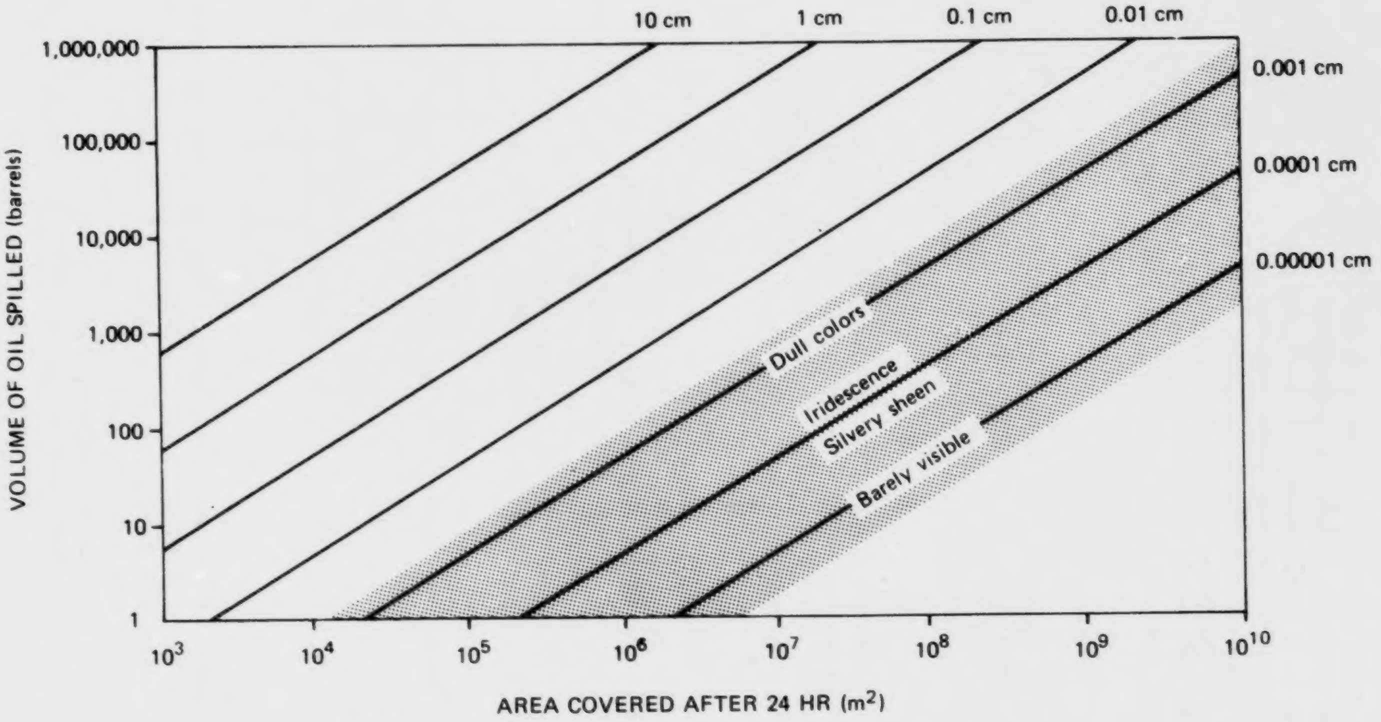
- When tankers or oil barge casualties are involved, volumes can be estimated if the cargo capacity and extent of hull damage are known. Although the extent of hull damage and oil loss cannot often be reliably estimated, total cargo capacity (by tank or ship) can be useful in setting maximum spill size.

- If a spill occurs during oil transfer, the total spill volume can be estimated if the pumping rate and the elapsed time between leak occurrence and pumping shutdown are known. The maximum pumping rate from the offloading source may be assumed to be the spill rate for a complete transfer, hose rupture, pipeline or manifold failure. Spills resulting from improper flange makeup or from hose leaks would be likely to occur at significantly lower rates.

- A rough estimate of spill volume can be calculated by considering slick area and average thickness. Figure 302-1 relates the appearance of oil on water to its thickness. These observations hold true for spills less than about 0.25 mm thick. Because large spills require significant time to spread to these thicknesses, a direct measurement of slick thickness would be preferable early in the spill.

Prediction of Spill Movement

The National Oceanographic and Atmospheric Administration (NOAA), under the NCP, has the responsibility of providing marine environmental data to the OSC. This data includes present and predicted meteorological, hydrological, and oceanographic conditions for the area in question. NOAA has developed computerized oil spill movement prediction models that can be used at the request of the OSC to predict which shoreline areas or offshore amenities are threatened by an oil spill.



Shaded area indicates the range of oil slick observations for which thickness and area covered can be determined by appearance. Any value below the shaded area would not be visible, and any value above would be a dark brown or black.

Figure 302-1. Volume, film thickness, appearance, and area covered by oil spills.

In the absence of sophisticated predictive modeling, on-scene personnel can predict initial oil slick movements by vector addition of the two main motive forces that apply: surface currents and winds. Observations from actual spill situations have shown that wind will cause an oil slick to move at between 0 and 4 percent of the wind speed, and in the same general direction. The exact percentage appears related to oil viscosity. For estimation purposes, a factor of three percent is generally acceptable. Figure 302-2 gives an example of the vector addition method of oil slick movement prediction. The general methodology for use of this technique is as follows:

1. Draw ocean current and wind component vectors in their relative directions and lengths as shown in Diagram 1 (length of vector represents velocity: 10 mm = 0.1 km/hr).

2. Draw a line parallel to the wind vector starting from the tip of the current vector and measuring the exact length of the wind vector, as shown in Diagram 2.

3. Draw a line from the point of origin (present oil slick position) to the tip of the parallel wind vector line in Diagram 3. This final line is the resultant vector which gives the direction and speed of the oil slick movement. The direction can be measured by using the cardinal points of a compass. The speed is determined by the length of the resultant vector. The resultant vector can also be used to estimate slick arrival time at points of interest along the path of movement.

In cases where winds and currents are unknown or variable, aerial reconnaissance is a useful tool for supplying input to predictive estimates, and tracking actual movements. Oil spills eventually cease to increase in size if the spill source is stopped. In such situations, and when conditions are calm, Figure 302-3 can be used to approximate probable spill radius. Calculations are based on a typical light crude oil (CLASS A) and may differ for other oils.

Slick Characteristics

The preceding discussion assumes the surface distribution of oil within a slick to be more or less uniform. While this assumption is adequate for gross movement and volume estimation, actual slicks are rarely uniform. Since the surface distribution of oil within a slick is important to treatment selection, it is useful to understand some basic characteristics of floating oil.

Figure 302-4 depicts the typical evolution of a larger slick. The initial slick spread in Zone A is governed by gravity and inertial forces. During this period the slick is relatively thick and its surface distribution tends to remain continuous. As the initial spreading forces decrease and such environmental factors as wind become important, windrow development is common. Zone B indicates the zone of windrow development. In Zone C, additional exposure results in windrow breakup and formulation of "minislicks." Typically the areas around and between minislicks and windrows are covered by

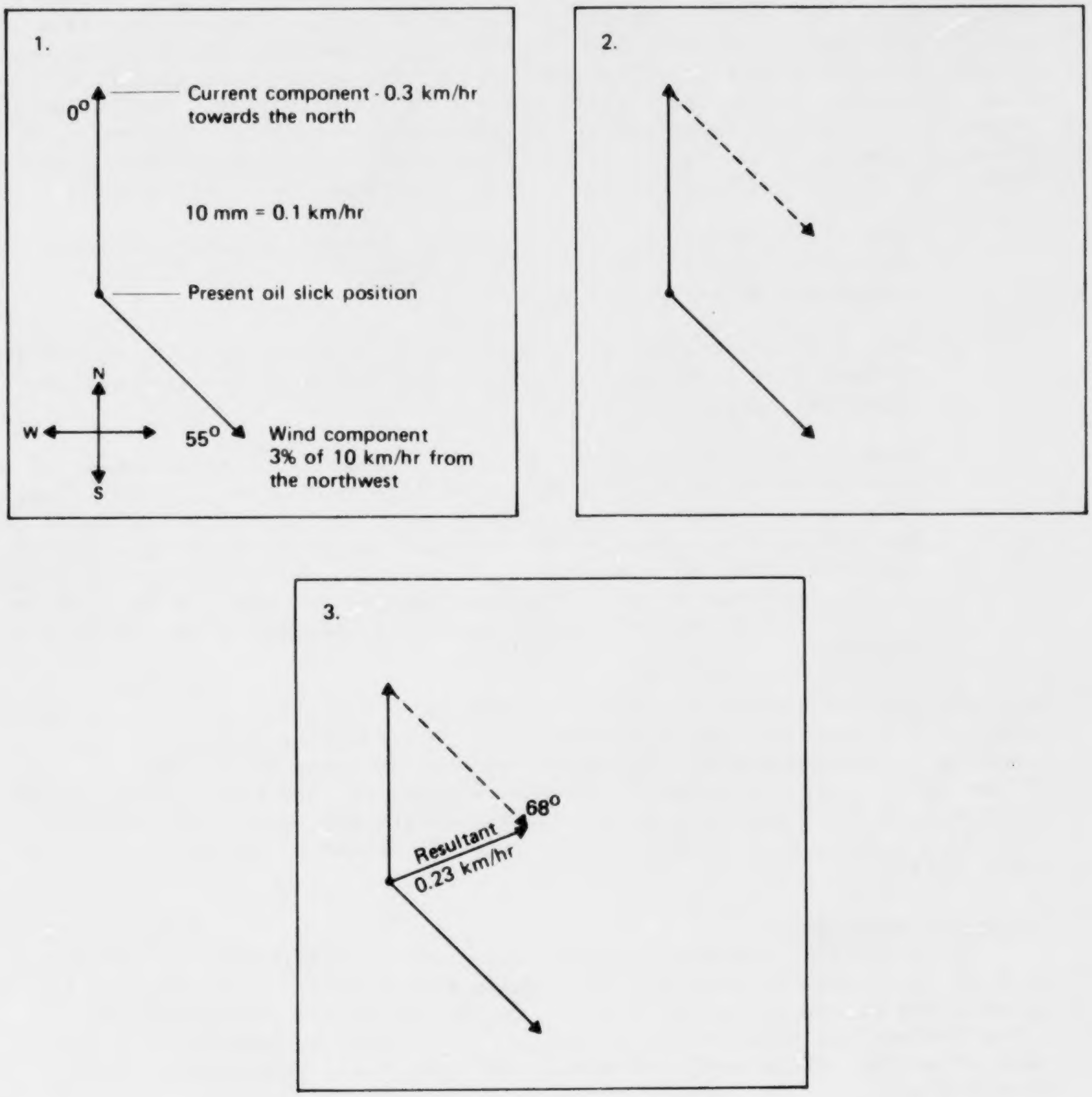

1.
0°
Current component - 0.3 km/hr towards the north
10 mm = 0.1 km/hr
Present oil slick position
N
W
S
55°
Wind component 3% of 10 km/hr from the northwest
2.
3.
68°
Resultant
0.23 km/hr

Figure 302-2. Vector addition for 10 km/hr NW wind and 0.3 km/hr north current.

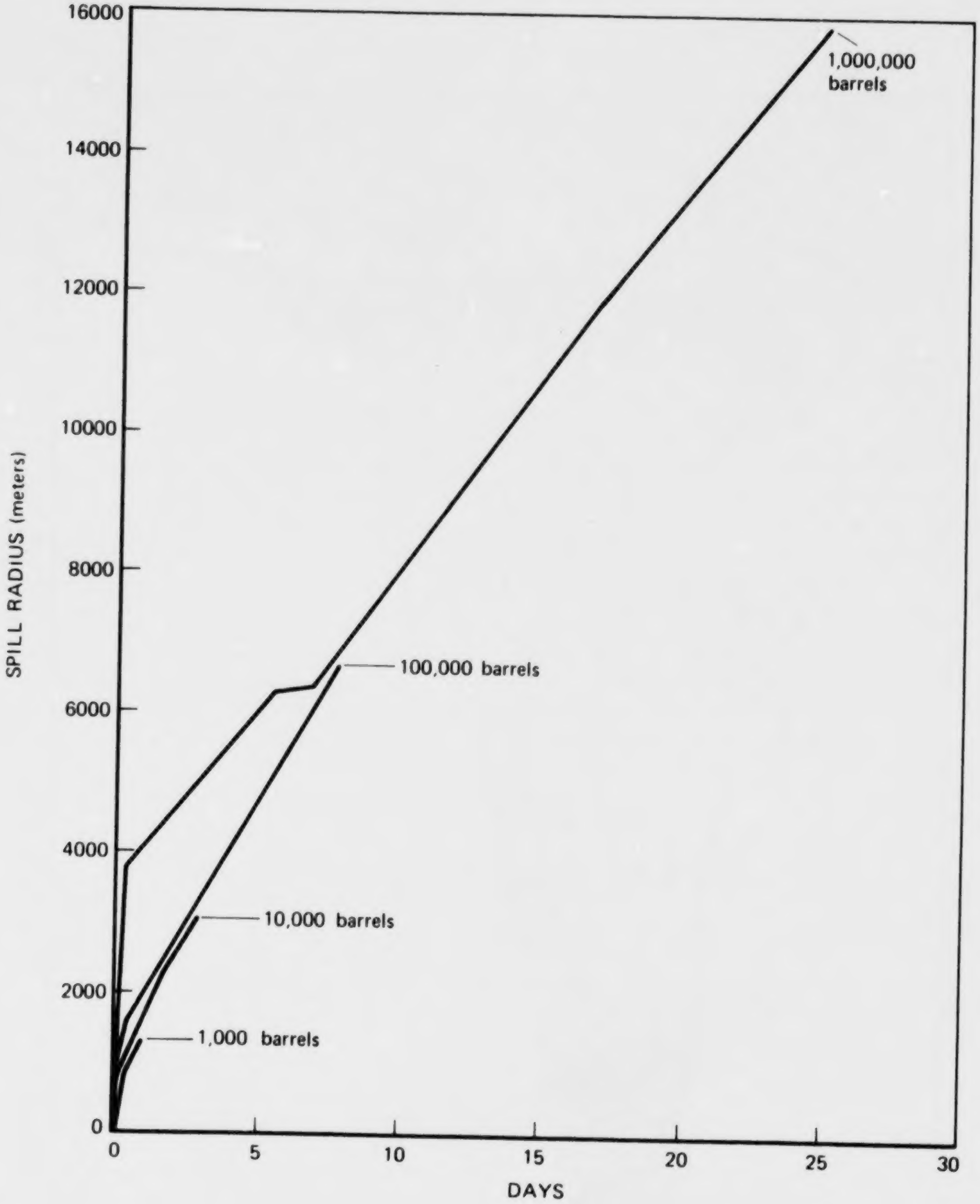


Figure 302-3. Maximum oil spill radius versus time (Fay-Hoult model).

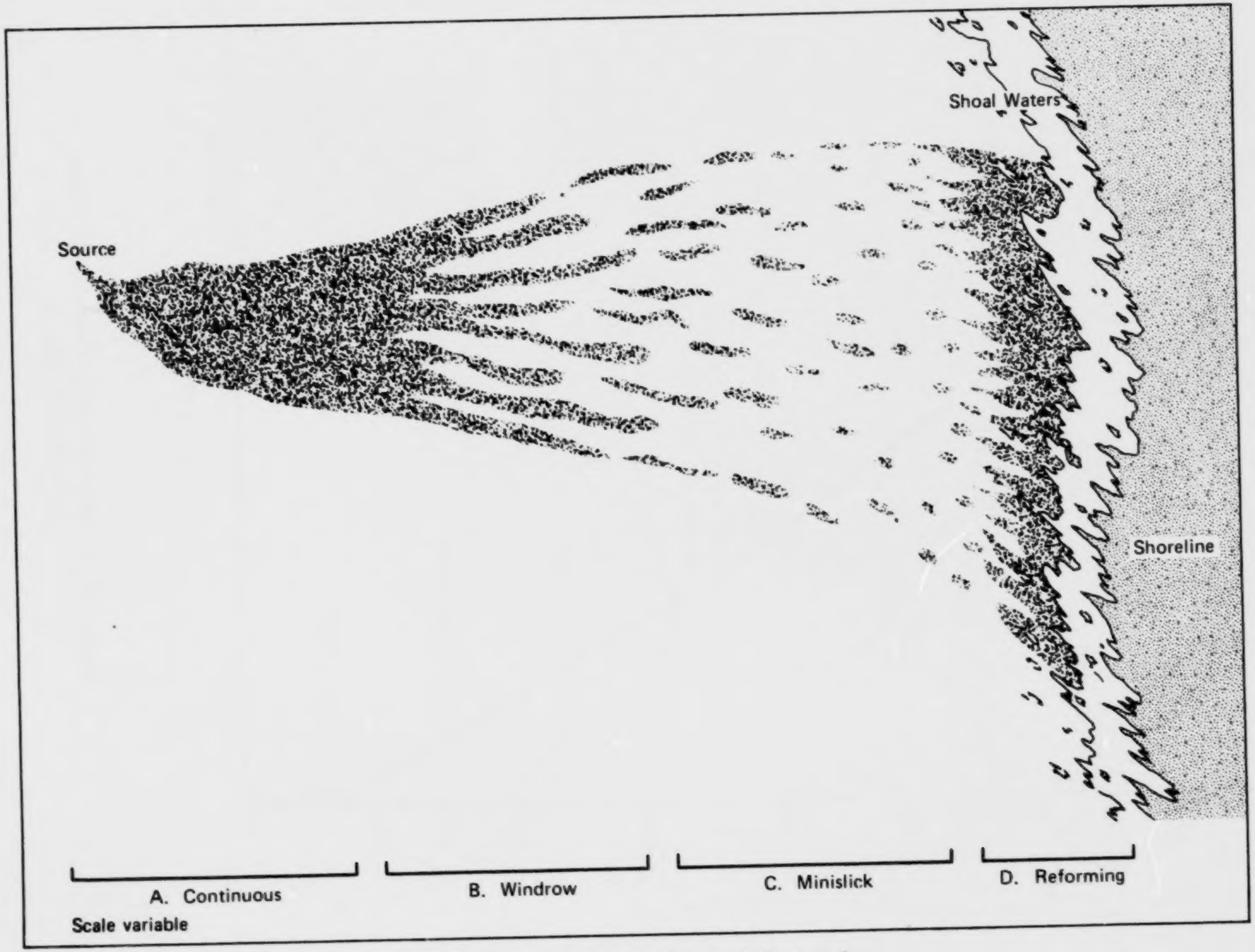


Figure 302-4. Typical evolution of slick surface.

thin sheens. These sheens reflect differential spreading rates encountered with some oils and the release of volatile fractions of more viscous oils.

If sufficient time and distance are available, a slick will ultimately disappear in Zone C. If the slick movement is impeded, however, remaining floating material may concentrate. This occurs commonly in response to the presence of shorelines and coastal currents, and is shown on Figure 302-4 as Zone D.

303 FIRE/EXPLOSION HAZARD

The threat of fire and explosion is associated with marine oil spills. The following rules should always be considered in the initial evaluation of an oil spill:

- Until otherwise established, all oil spills - particularly those involving gasolines or continuous spillage (pipeline breaks, well blow outs, etc.) should be considered as fire hazards.

- Any spills (light refined products and light crude oil in particular) involving confined airspace in which vapors may concentrate (shipboard tankage and machine spaces, under docks, etc.) should be considered potentially explosive.

Chemical dispersants may be particularly useful in fire control and reduction of fire and explosion hazard. In situations where such hazards threaten human life and property, federal regulations allow the On-Scene Coordinator to wave normal use restrictions and take immediate action. Figure 303-1 is a decision guide to assist in the determination of hazards and appropriate actions. As with any general guide, exceptions can exist. Each case should be evaluated with utmost caution.

Fire hazard will normally diminish rapidly with time and distance from the source. When in doubt, the potential fire hazard an oil spill presents can be established by:

(1) determining flash point of the oil, or

(2) determining hydrocarbon vapor content of the air near the surface of the slick by using an explosive gas detector

The flash point is the temperature at which the vapors rising from the surface of the oil will ignite with a flash of very short duration when a flame is passed over the surface. If the flash point of the spilled oil is close to or below the ambient air temperature, the oil poses a fire hazard. The minimum flash point and flammability limits for common refined petroleum products are given in Table 303-1.

Prevailing weather conditions can affect the hazard potential of the spilled oil. A calm, hot day could accentuate vapor buildup. Strong winds (greater than 15-20 knots), on the other hand, will tend to disperse the vapors below the flammability limit, considerably reducing the fire hazard.

In addition to the oil, flammability of the dispersant should be considered in the control of fire and explosion hazard. Hydrocarbon base dispersants should not be applied for control of fire hazard if nonflammable (water solvent) types are available, nor should they be used in the vicinity of open flame. Flash point data for EPA approved dispersants is given in the Annex X data submissions.

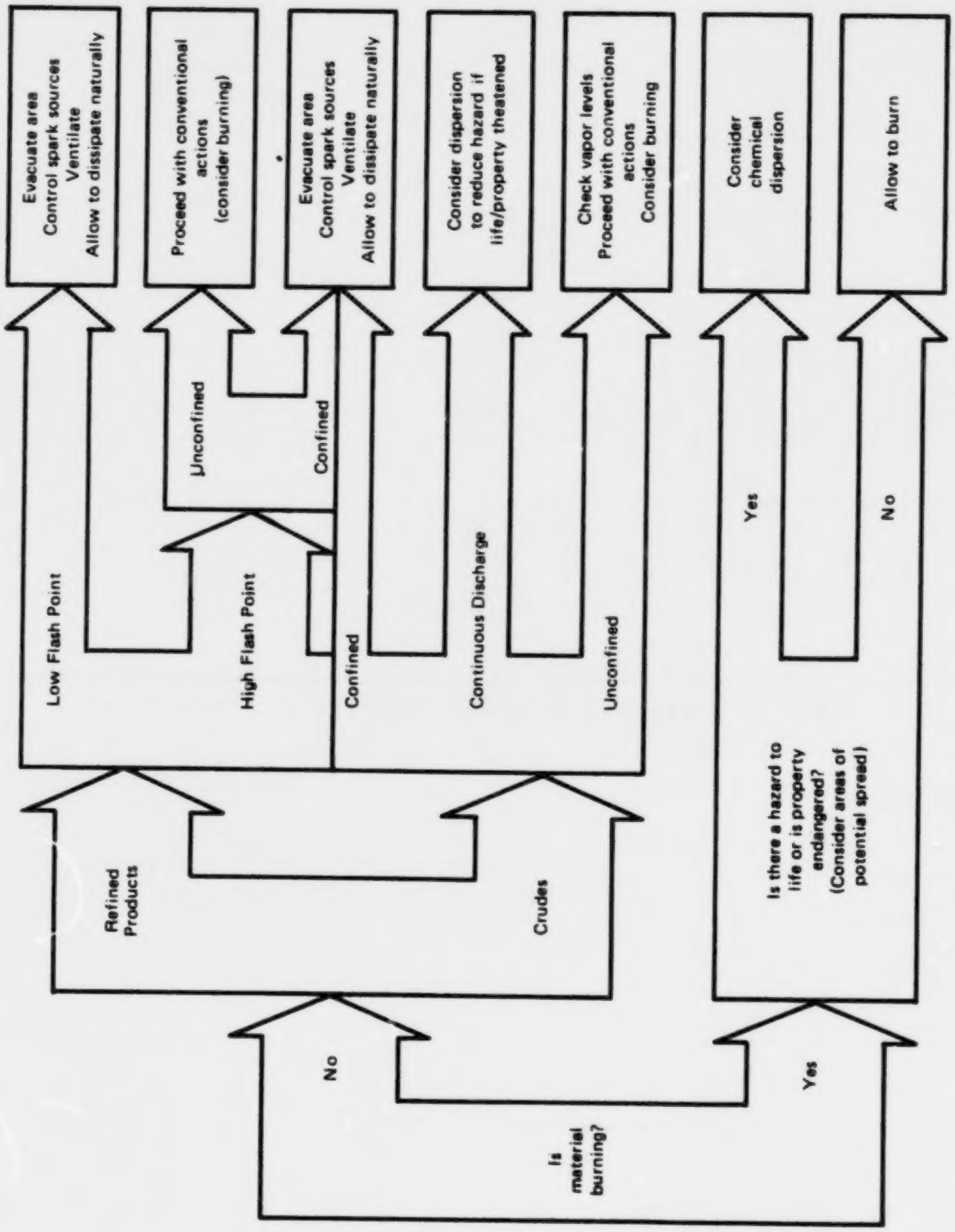

Is material burning?
No
Yes
Refined Products
Crudes
Low Flash Point
High Flash Point
Confined
Continuous Discharge
Unconfined
Unconfined
Confined
Is there a hazard to life or is property endangered? (Consider areas of potential spread)
Yes
No
Evacuate area Control spark sources Ventilate Allow to dissipate naturally
Proceed with conventional actions (consider burning)
Evacuate area Control spark sources Ventilate Allow to dissipate naturally
Consider dispersion to reduce hazard if life/property theatened
Check vapor levels Proceed with conventional actions Consider burning
Consider chemical dispersion
Allow to burn

Figure 303-1. Decision guide - fire hazard and response.

Table 303-1. FLASH POINTS AND FLAMMABILITY LIMITS OF REFINED PETROLEUM PRODUCTS

		Flash Point (°C)	Flammable Limits in Air
Aviation Gasoline		-59.8	1.2%-7.1%
Automobile	Gasoline	-57.0 → 52.0	1.4%-7.4%
	Naptha	-20.9	0.9%-6.0%
	Kerosene	23.6 → 29.1	0.7%-5%
Jet Fuels:	JP-1	23.6	0.7-5%
	JP-3	29.1 → 51.3	Not Known
	JP-4	-37.6 → -15.3	1.3%-8.0%
	JP-5	45.8	0.6%-4.6%
Diesel Fuels			
	1D	23.6	1.3-6.0%
	2D	37.4	1.3-6.0%
Residual Fuel Oils			
	No. 4	>40.2	1-5%
	No. 5	>40.2	1-5%
	No. 6	>51.3	1-5%

Source: CHRIS, Hazardous Chemical Data, U.S. Coast Guard CG-446, 1974.

SECTION 400

CRITERIA FOR DISPERSION OF OIL AT SEA

401 GENERAL

This section provides a rationale for determining, case-by-case, the acceptability of chemical dispersion of oil at sea. This rationale, presented graphically in Figure 401-1, consists of a series of basic questions. Does the spill present a threat to shorelines or sensitive areas or amenities? If a threat is identified, is it probable that conventional control and recovery actions will be adequate? Is the oil type dispersible, and can an effective dispersion operation be implemented? Are the probable impacts associated with dispersed oil less than those expected without such action? The following subsections provide criteria for evaluating these basic questions.

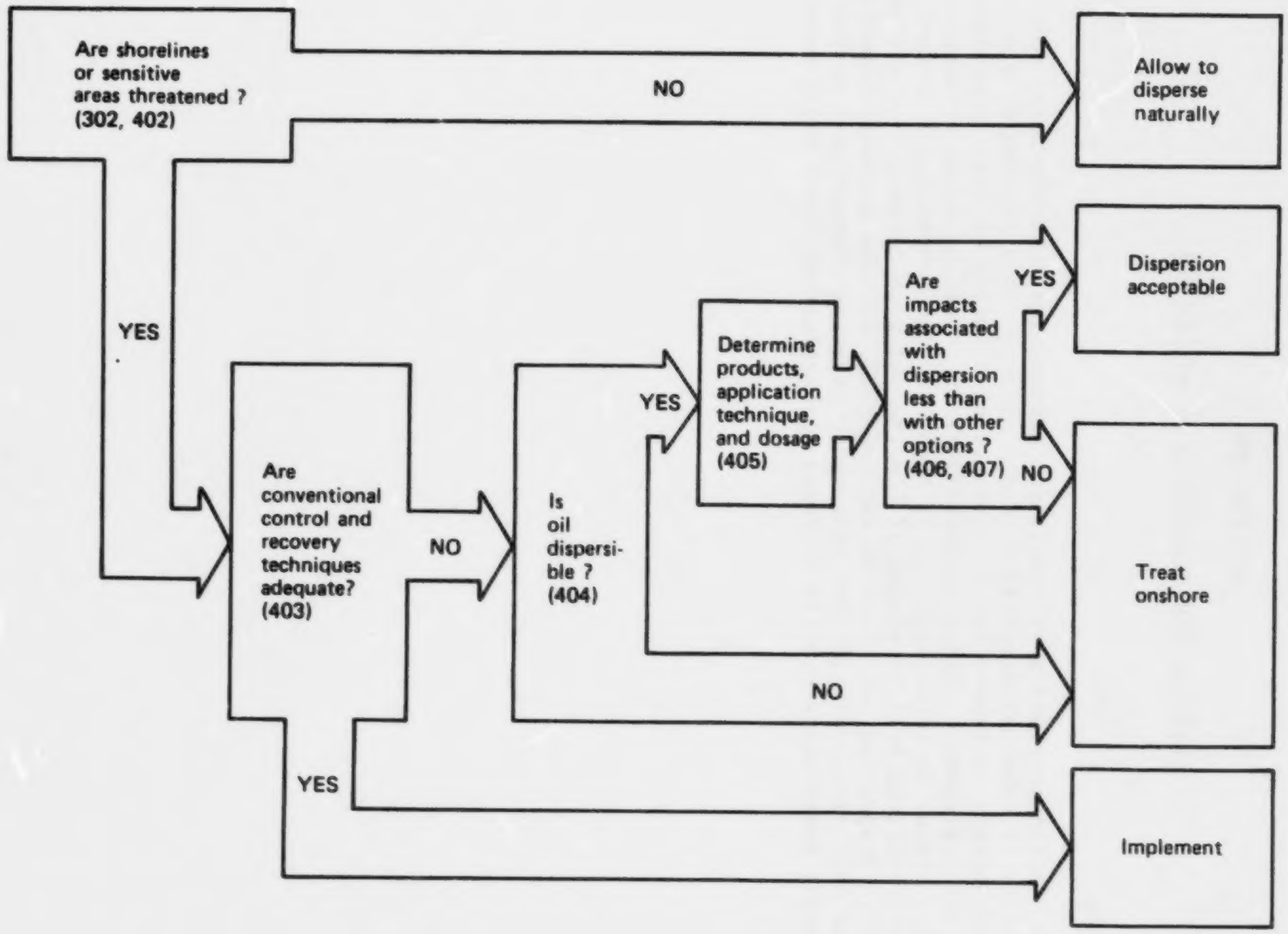


Figure 401-1. Decision guide - dispersion of floating oil.

402 IDENTIFICATION OF THREATENED AREAS

In Section 302 general slick movement is projected. Amenities in the general path of movement including special features, resources, and uses that are of particular biological, physical, or cultural importance can be identified and plotted. The relative importance of amenities in an area can vary with the season, severity, and duration of the expected impact and potential for recovery. Because of the high visibility of special features, resources, and uses in an area, and of the limitations of time, manpower, and equipment in responding to a spill, rapid identification of the amenities becomes a critical part of the dispersant question. Local and regional experts can provide necessary information on the nature and location of relevant environmental concerns. In general, the probable effects of oil and oil dispersions should be considered for the general amenities listed in Table 402-1. This table also provides brief evaluation criteria.

TABLE 402-1. SPECIAL FEATURES, RESOURCES, AND USES

---

1. Rare, Threatened, Endangered, or Protected Species

- Any species on federal or state special status lists.
- Relatively few expected in marine areas, some in estuaries, most in fresh water.
- Sensitivity will depend on the reason the species uses the aquatic habitat, duration of use, importance of the habitat to successful completion of the species life cycle, and public and political concern for the species.
- In general, sensitivities in decreasing order are: 1) resides in aquatic habitat and completes whole life cycle in one place, 2) habitat essential for breeding purposes, 3) habitat essential for feeding purposes, and 4) habitat essential for resting and other intermittant uses.

2. Reserves, Preserves, and Other Legally Protected Areas

- Areas protected by some legal mandate or areas locally recognized as important for scientific or ecological reasons.
- Areas of special biological significance.
- Ecological preserves.
- Wildlife and/or waterfowl sanctuaries and refuges.
- Scientific research areas.

3. Waterfowl Rookery or Concentration Areas

- Shoreline areas (rookeries) used for breeding, nesting, and fledging activities.
- Open-water areas (concentration) used for resting, feeding, and breeding
- Sensitivity will depend on which species are present; number, extent, reason for use of the habitat; and susceptibility to oil impacts.
- In general, sensitivities in decreasing order are: 1) diving ducks, 2) swimming and surface-feeding waterfowl, 3) gulls, terns, etc., 4) shorebirds and 5) water-associated birds.

TABLE 402-1 (Continued). SPECIAL FEATURES, RESOURCES, AND USES

---

4. Mammal Rookeries, Calving Grounds, and Concentration Areas

- Sensitivity will depend on which species are present; number, extent, reason for use of the habitat; and susceptibility to oil and dispersion impacts.
- In the marine environment, rookeries, and calving grounds are generally more sensitive to oil impacts than are concentration (haul-out) areas.

5. Species of Commercial Importance

- Clams and oysters.
- Crabs, shrimp, lobsters.
- Finfish (including spawning areas offshore, intertidal, and in shallow streams).
- Algae.
- Aquaculture sites (shellfish, algae, finfish, lugworms etc.).
- Fish bait (lugworms, clams, ghost shrimp etc.).
- Sensitivity will depend on season, economic value of the local harvest to the area, and susceptibility to oil and dispersion impacts.

6. Species of Recreational Importance

- Clams, oysters, mussels.
- Crabs, shrimp, lobsters, ghost shrimp, lugworms, etc.
- Finfish (shoreline fishing areas, spawning areas for grunnion, salmon, bass, and other fish).
- Abalone.
- Sensitivity will depend on season, use, and susceptibility to oil and dispersion impacts.

7. Ecologically Productive Areas

- Eelgrass beds.
- Marshes and other wetlands.

TABLE 402-1 (Continued). SPECIAL FEATURES, RESOURCES, AND USES

- Estuaries.
- Coral Reefs.
- Mangroves.
- Some kelp beds.
- Areas critical to survival of local population of species known to be of major ecological significance in structure, function, stability, and survival of the aquatic community.

8. Areas of Beach Stabilizing Vegetation

- Vegetation stabilizing sand dunes important to protecting backshore areas.
- Vegetation preventing shoreline banks from erosion.

9. Areas of Geological Significance

- High erosion potential areas.
- Specially designated geological study areas.
- Fossiliferous formations.
- Mineral-bearing sediment deposits.

10. Areas of Recreational Significance

- Marinas and boat harbors.
- State parks and beaches.
- Sunbathing, surfing, and swimming beaches.
- Beaches with shore-front homes.
- Beaches with shore-front hotels and restaurants.
- Beaches adjacent to roads and highways.

11. Areas of Commercial or Industrial Significance

- Cooling water intakes.
- Process water intakes.

403 ASSESSMENT OF CONVENTIONAL CONTROL AND RECOVERY

Federal policy advocates physical control and recovery of spilled oil using conventional techniques (i.e., booms, skimmers, etc). The adequacy of physical control and recovery of an oil spill at sea is dependent on a variety of factors including:

- prevailing meteorological and oceanographic conditions
- physical properties of the spilled oil
- availability of suitable oil spill control and recovery equipment

The decision guide (Figure 403-1) illustrates how these factors can be evaluated to determine the feasibility of containing and cleaning up an oil spill at sea.

Sea State Conditions

The first factor to consider is the prevailing and predicted meteorological and oceanographic conditions, which can be expressed as sea state. Figure 403-2 illustrates how sea state can be estimated from wind speed and wave heights. It also indicates the limitations of containment booms and oil skimmers for various sea states. Generally, even containment booms and skimming equipment rated for open sea conditions quickly lose effectiveness once sea state 3 is surpassed. Therefore, if a sea state of 4 (i.e., breaking waves over 5 feet) or greater is present and predicted for several days, mechanical containment and cleanup techniques would be of limited effectiveness or ineffective in controlling the spill.

Oil Properties

Skimmer recovery is affected by the physical state of the oil. High viscosity and nonflowing oils are more difficult to recover and can considerably reduce a skimmer's effectiveness.

Logistics

The availability of sufficient equipment and response time for implementation comprises the final assessment factor. A checklist for determining the feasibility of containment and skimming operations is given in Table 403-1. If the answer to all questions is affirmative, then booming and skimming operations should be feasible. If one or more answers are negative, the physical control of the spilled oil might not be totally effective, and consideration is given to other alternate or supplemental techniques (i.e., chemical treatment).

The length of boom needed to contain a fresh oil slick at sea is dependent on the time required for its deployment and the volume of oil spilled. As a slick spreads and thins out on the water surface it tends to break into long narrow windrows in response to wind and wave conditions. This action greatly increases the slick perimeter and consequently the amount of boom needed for containment.

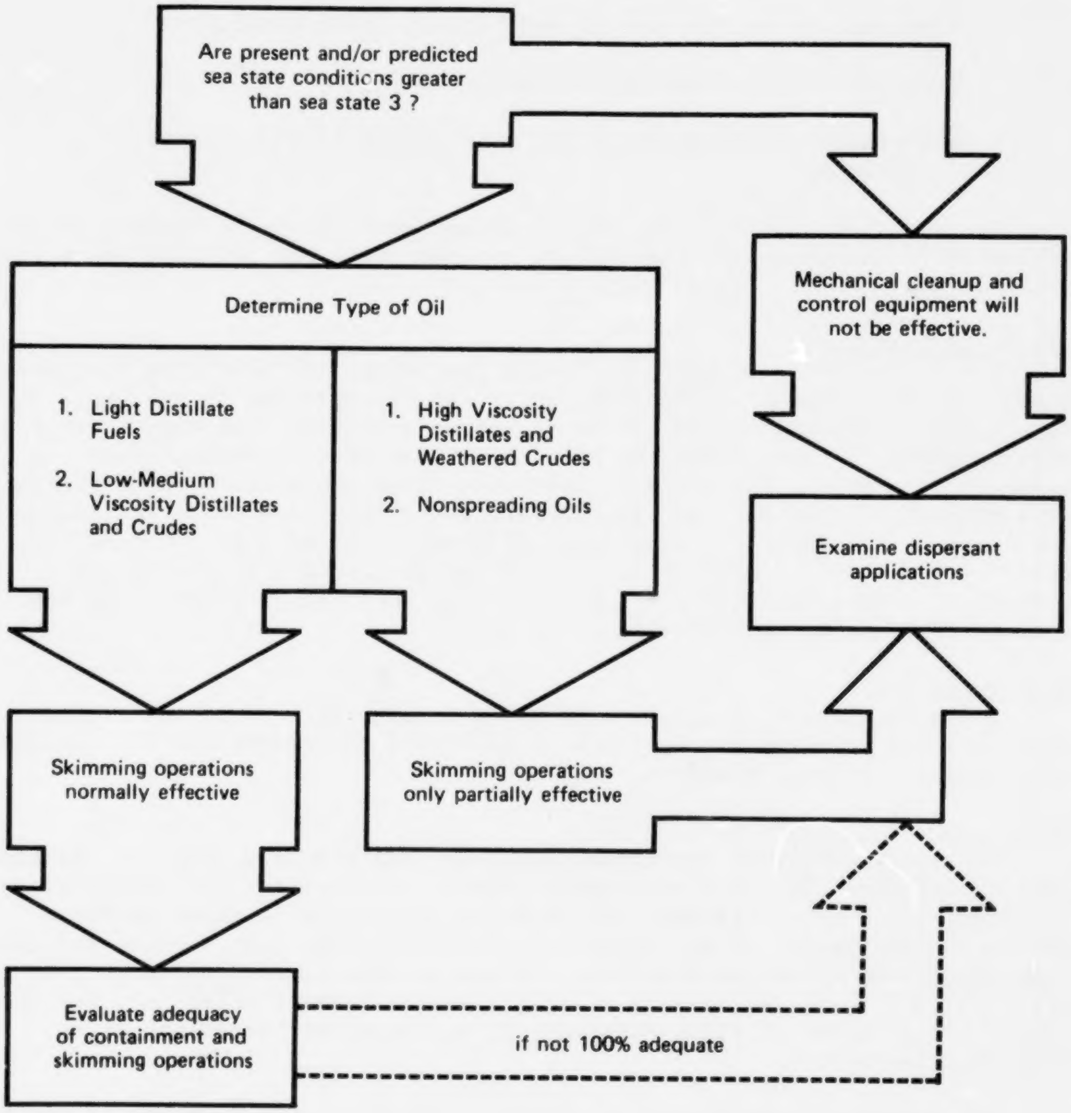
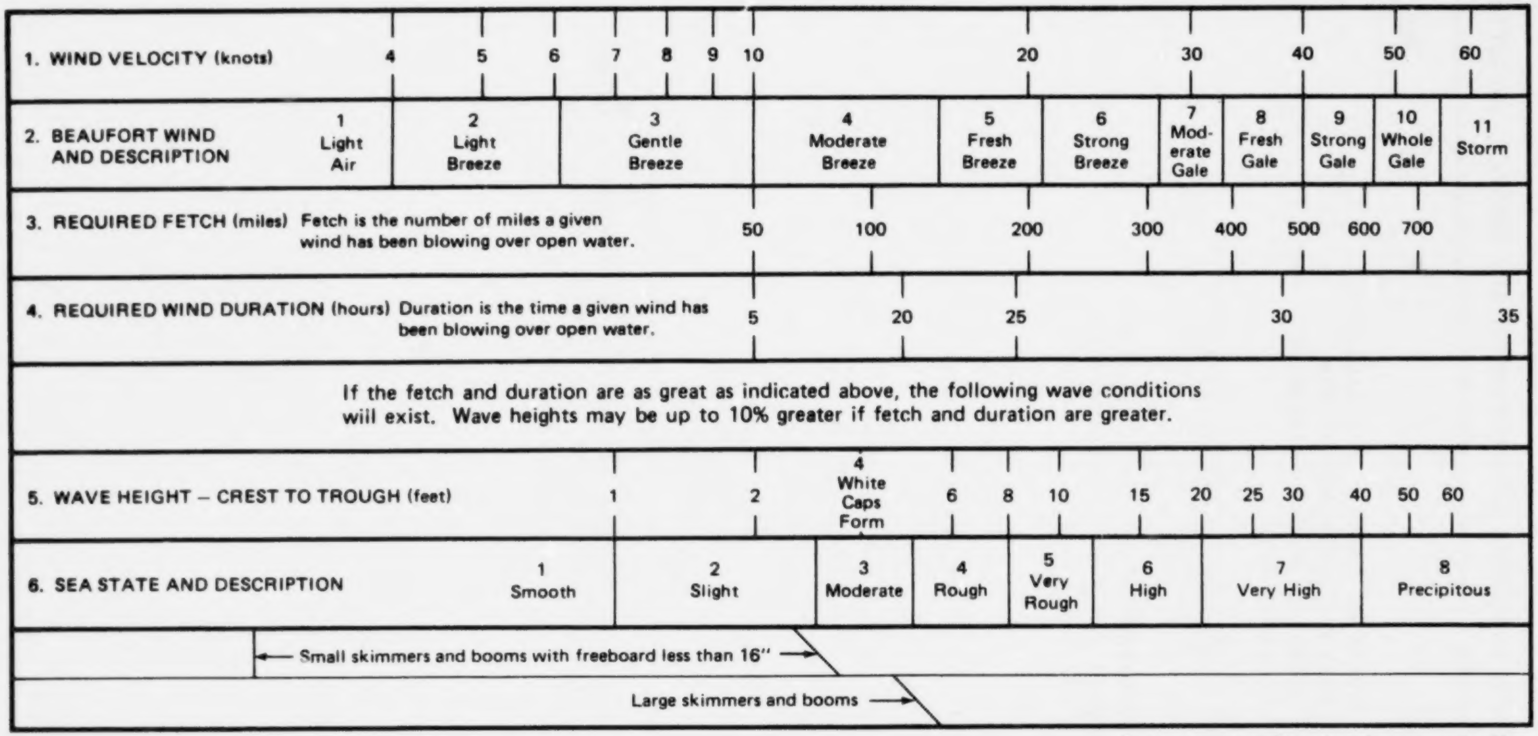

Are present and/or predicted sea state conditions greater than sea state 3 ?
Determine Type of Oil
1. Light Distillate Fuels
2. Low-Medium Viscosity Distillates and Crudes
1. High Viscosity Distillates and Weathered Crudes
2. Nonspreading Oils
Skimming operations normally effective
Skimming operations only partially effective
Evaluate adequacy of containment and skimming operations
if not 100% adequate
Mechanical cleanup and control equipment will not be effective.
Examine dispersant applications

Figure 403-1. Assessment quide for mechanical control and recovery.


1. WIND VELOCITY (knots)
4 5 6 7 8 9 10 20 30 40 50 60
2. BEAUFORT WIND AND DESCRIPTION
1 Light Air
2 Light Breeze
3 Gentle Breeze
4 Moderate Breeze
5 Fresh Breeze
6 Strong Breeze
7 Mod-erate Gale
8 Fresh Gale
9 Strong Gale
10 Whole Gale
11 Storm
3. REQUIRED FETCH (miles) Fetch is the number of miles a given wind has been blowing over open water.
50 100 200 300 400 500 600 700
4. REQUIRED WIND DURATION (hours) Duration is the time a given wind has been blowing over open water.
5 20 25 30 35
If the fetch and duration are as great as indicated above, the following wave conditions will exist. Wave heights may be up to 10% greater if fetch and duration are greater.
5. WAVE HEIGHT – CREST TO TROUGH (feet)
1 2 4 White Caps Form 6 8 10 15 20 25 30 40 50 60
6. SEA STATE AND DESCRIPTION
1 Smooth
2 Slight
3 Moderate
4 Rough
5 Very Rough
6 High
7 Very High
8 Precipitous
Small skimmers and booms with freeboard less than 16"
Large skimmers and booms

Note: Corresponding values lie on a vertical line.

This table applies only to waves generated by the local wind and does not apply to swell originating elsewhere.

WARNING: Presence of swell makes accurate wave observation exceedingly difficult.

NOTE: a. The height of waves is arbitrarily chosen as the height of the highest 1/3 of the waves. Occasional waves caused by interference between waves or between waves and swell may be considerably larger.

b. The above values are only approximate due both to lack of precise data and to the difficulty in expressing it in a single easy way.

Figure 403-2. Wind waves at sea.

TABLE 403-1. CHECKLIST FOR LOGISTICS OF CONTAINMENT AND RECOVERY OPERATIONS

Containment or Protection	Yes	No
1. Is there sufficient length of boom(s) available for use (Length needed - approximately 60% of the perimeter of the oil slick or slicks or 125% of perimeter of area to be protected)	___	___
2. Are vessels and crews available to transport and deploy boom	___	___
3. Can the boom(s) be deployed before the slick contacts shoreline (Compare ETA of oil on shore with estimated deployment time of booms)	___	___
Recovery		
1. Are skimmers available which can operate under open sea conditions	___	___
2. If so, is the combined pickup rate of the skimmers sufficient to pick up most of the oil in a reasonable time*	___	___
3. Is there sufficient storage available for the skimmers to offload recovered oil without disrupting or delaying the skimming operations	___	___

*If the discharge is continuous, can the skimmers pick up the oil volume discharged daily, or if the discharge is of short duration, can the skimmers pick up the spilled oil in 10 to 15 days.

The areal extent and thickness of an oil slick is important in determining the number of skimmers needed for recovery operations. The amount of oil a skimmer encounters during a skimming operation is the primary factor in determining recovery rate. Many large ocean skimmers are capable of pumping 6,000 to 10,000 gallons of oil per hour; however, that large a volume of oil would rarely be encountered.

Figure 403-3 can be used to estimate the encounter rate of a skimmer with a known sweep width and skimming speed for various surface concentrations of oil. The encounter rate multiplied by the skimmer efficiency gives an estimate of oil recovery. For instance, if a skimmer with a sweep width of 20 feet was operating in a 0.1 mm oil slick at a skimming speed of 2 knots, it would encounter approximately 600 gallons of oil in one hour. If the skimmer has a recovery efficiency of 90 percent (i.e., it recovers 90 percent of the oil it encounters) it would pick up approximately 540 gallons of oil per hour. The encounter rates do not reflect any time lost for manuvering, offloading of recovered oil or transit time to an offloading site. Therefore, when estimating skimmer recovery rates only the actual time spent in skimming should be used to determine an expected daily recovery rate.

Partial Effectiveness

In many cases conventional control and recovery techniques may be limited to certain parts of the spill due to adverse conditions or the sheer magnitude of the spill. In this event, both chemical treatment and conventional techniques should be considered to provide maximum overall effectiveness and minimum damage.

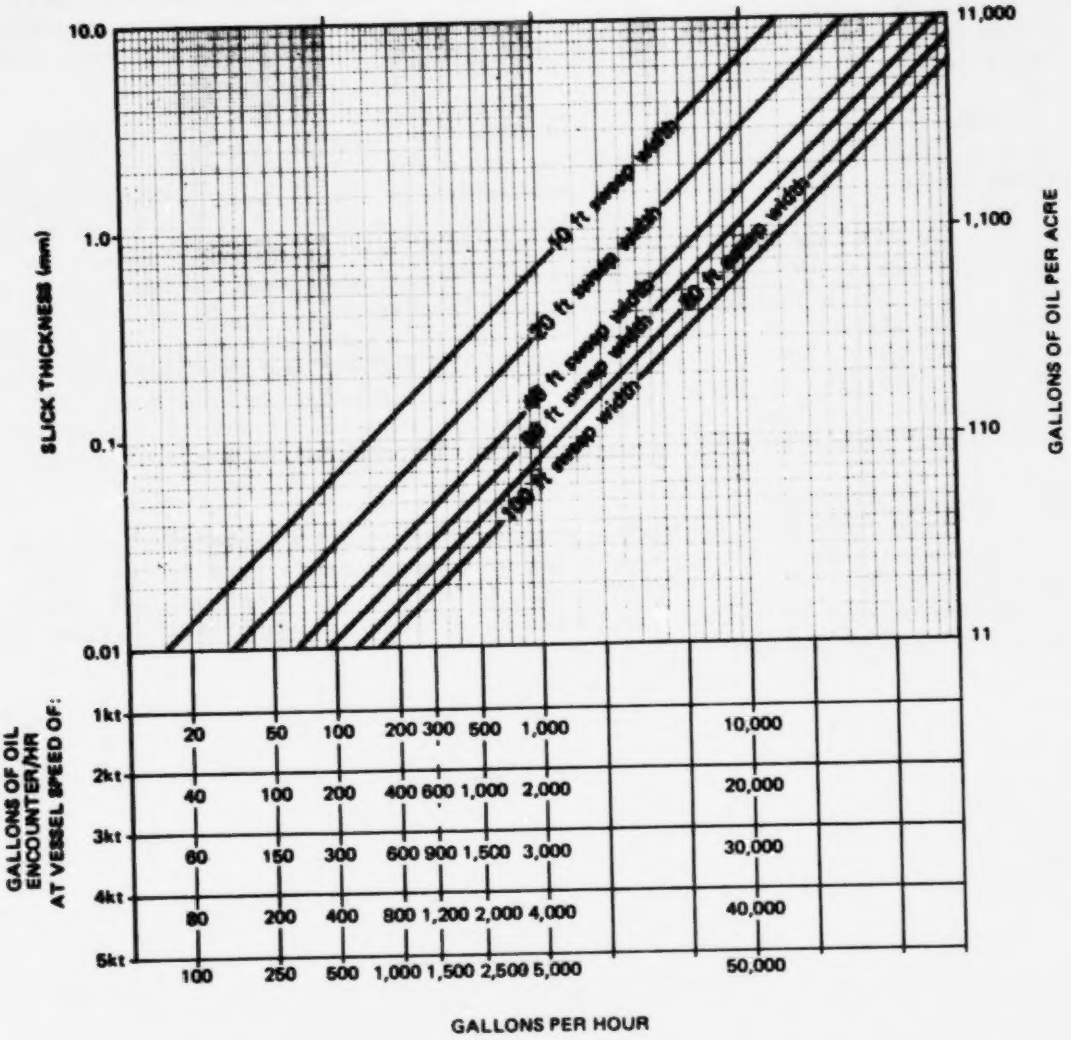


Figure 403-3. Encounter rates of skimmers for different sweep widths and vessel speeds versus slick thickness.

404 OIL DISPERSABILITY

Dispersant Selection

The effectiveness of any particular dispersant application is dependent on a combination of factors including oil type and condition, dispersant type and dosage, mixing energy, and temperature. Typically, dispersants are most effective on the least persistent (more volatile) oils and less effective on the more persistent oils. In some cases (i.e., nonspreading oil) chemical treatment may have little or no effect.

Dispersants contain surface active agents which reduce the oil-to-water interfacial tension. In the presence of energy supplied by natural or mechanical mixing - or in some cases by molecular diffusion, formation of oil droplets is enhanced. Coatings on each oil droplet prevent their reforming. Dispersant formulations may be divided into three basic types: those which contain surface active agents carried in a hydrocarbon (hydrocarbon base) solvent; those which contain surface active agents carried in an aqueous solvent (commonly water or alcohol-water base); and those which contain high concentrations of active ingredients in relation to the carrier (concentrate).

Table 404-1 lists the compatibility of major oil categories with dispersant types. From this table, a few general rules can be developed.

- Oils having a pour point less than the ambient water temperature cannot be successfully chemically dispersed.
- High viscosity (low spreading rate oils) may be difficult to disperse effectively.

TABLE 404-1. OIL TYPE: DISPERSANT COMPATABILITY

Oil Category	Dispersant Type		
	Water Base	Hydrocarbon Base	Concentrate
A Low viscosity, high spreading rate oils and products	X^1		X^1
B Moderate or high viscosity waxy oils		X^2	X^2
C High viscosity low spreading rate oils		X	X^2
D Non-spreading oils	Chemical dispersion not effective		

[1] Dispersion of highly volatile products not recommended except to control extreme fire/explosion hazard

[2] Effectiveness may be limited

405 DETERMINATION OF APPLICATION TECHNIQUE, PRODUCT, AND DOSAGE

Application Technique

Application techniques compatible with each generic type of dispersant are listed in Table 405-1. A number of techniques may be applicable to each type, however, there is no established formula for selecting among the possibilities. Selection may be dictated by dispersant and equipment availability, any limiting operating conditions, and spill magnitude. In the event of a large spill, all available systems may be required.

Factors to consider in selecting the optimum technique should include sea state, spill characteristics, logistics, desired treatment rate, need for supplementary mixing energy, and cost. Table 405-2 can assist the user in the selection process by comparing advantages and disadvantages of respective application techniques.

Product Selection

A dispersant product must comply with federal requirements concerning the submission of technical data to be considered for use. Figure 405-1 presents a product selection approach which uses a screening and ranking process. Generally, products are generically identified by their manufacturer. In cases where they are not, they may be categorized using data required by Annex X. Candidate products can be listed in the dispersant selection worksheet provided in Figure 405-2. By recording appropriate data, products having undesirable properties can be preliminarily screened. Undesirable properties, criteria for their evaluation, and data references required by Annex 10 are listed in Table 405-3. The acceptability of each criteria will probably involve subjective user evaluation.

Products remaining after this screening are then ranked for relative effectiveness and toxicity using the test data required by the worksheet. These data are based on laboratory tests and are therefore only suggestive of what may be encountered in the field.

Dosage

Most products are supplied with dosage recommendations, normally in terms of dosage per acre or as a dispersant-to-oil ratio. These recommendations are based on manufacturers' experimentation and experience and are suitable starting dosages. Dosages beyond that required to achieve a satisfactory dispersion should not be used. Manufacturers' representatives may be consulted for unusual oils or conditions. Typically, experimentation with initial applications will be required.

In field situations oil distribution is commonly irregular and quantities difficult to estimate. Under such circumstances an average or optimum dosage must be used. Accordingly, some manufacturers supply a recommended dosage per acre for general use. Such dosages are acceptable for initial application, with adjustments made as appropriate after test applications.

For products where dosage is given in terms of a dispersant-to-oil ratio, calculation of a usable application rate is necessary. Figure 405-3

TABLE 405-1. APPLICATION SYSTEM: DISPERSANT TYPE COMPATIBILITY

Application System	Dispersant Type		
	Water. Base	Hydrocarbon Base	Concentrate
Hand Spray			
Neat	X	X	X
Vessel Spray Systems			
< 20 GPM			
Neat	X	X	
Injection into seawater stream	X		X
> 20 GPM			
Injection into seawater stream	X		X
Eduction into seawater stream	X		X
Fire Systems (portable and fixed)			
Eduction into seawater stream	X		X
Aerial Systems			
Neat	X	X	X

TABLE 405-2. ADVANTAGES AND DISADVANTAGES OF MAJOR DISPERSANT APPLICATION SYSTEMS

SYSTEM	ADVANTAGES	DISADVANTAGES
Hand Spray	Equipment readily available, spray may be accurately directed	Limited coverage rate, dosage difficult to control, no provision for external mixing
Vessel Systems (General)	May be used on vessels of opportunity, larger vessels provide high dispersant capacity and duration on station, effective in treating windrows	Slow operational and transit speeds limit total coverage per day, operation in high seas may be hazardous, spotter aircraft may be required
Vessel Systems (<20 GPM)	Packaged systems available (WSL-type), can be used in conjunction with breaker boards to supply additional mixing energy, good control of dosage	Flow rate too low for eduction of concentrate dispersants, outriggers and breaker boards limit maximum operational sea state
Vessel Systems (>20 GPM)	Packaged systems available, can be used with breaker boards to supply additional mixing energy, with dilutable dispersants effective operating characteristics extended	Output is generally too high for heat applications, outriggers and breaker boards limit maximum operational sea state
Vessel Systems (Fixed fire monitor or pump/hose systems)	Pumps, monitors, eductors commonly built into vessels, minimal operator requirements, spray imparts some mixing energy, can operate in slightly higher sea states than outrigger systems	Spray distribution may be irregular
Vessel Systems (Trained fire monitor or pump/hose systems)	Dispersant may be directed to oil concentrations, may use existing fire systems, spray may be used for mixing	No control of dosage, operator(s) required
Aerial Systems (General)	High application rates and low response times, can operate in higher sea states than most vessels, better visual monitoring of slick than vessels	Operation precluded in low visibility, no provision for adding external energy, high or cross winds tend to interfere with application
Aerial Systems (Helicopter)	Highly manueverable, rapid response, many systems adapt to most aircraft, operating base requirements minimal	Limited dispersant capacity, cargo must be traded for fuel for long-range applications
Aerial Systems (Light agricultural aircraft)	Fair availability in most areas, adaptation of agricultural systems rapid and simple (nozzle modification), good maneuverability, minimal airfield requirements (dirt air strip)	Limited dispersant capacity, typically must operate in sight of land, may be difficult to achieve desired single-pass dosage
Aerial Systems (Heavy aircraft)	High capacity and extended operating range	Systems not common, maneuverability limited during application, spotter planes required, full-size airfield required, may be difficult to achieve desired single-pass dosage

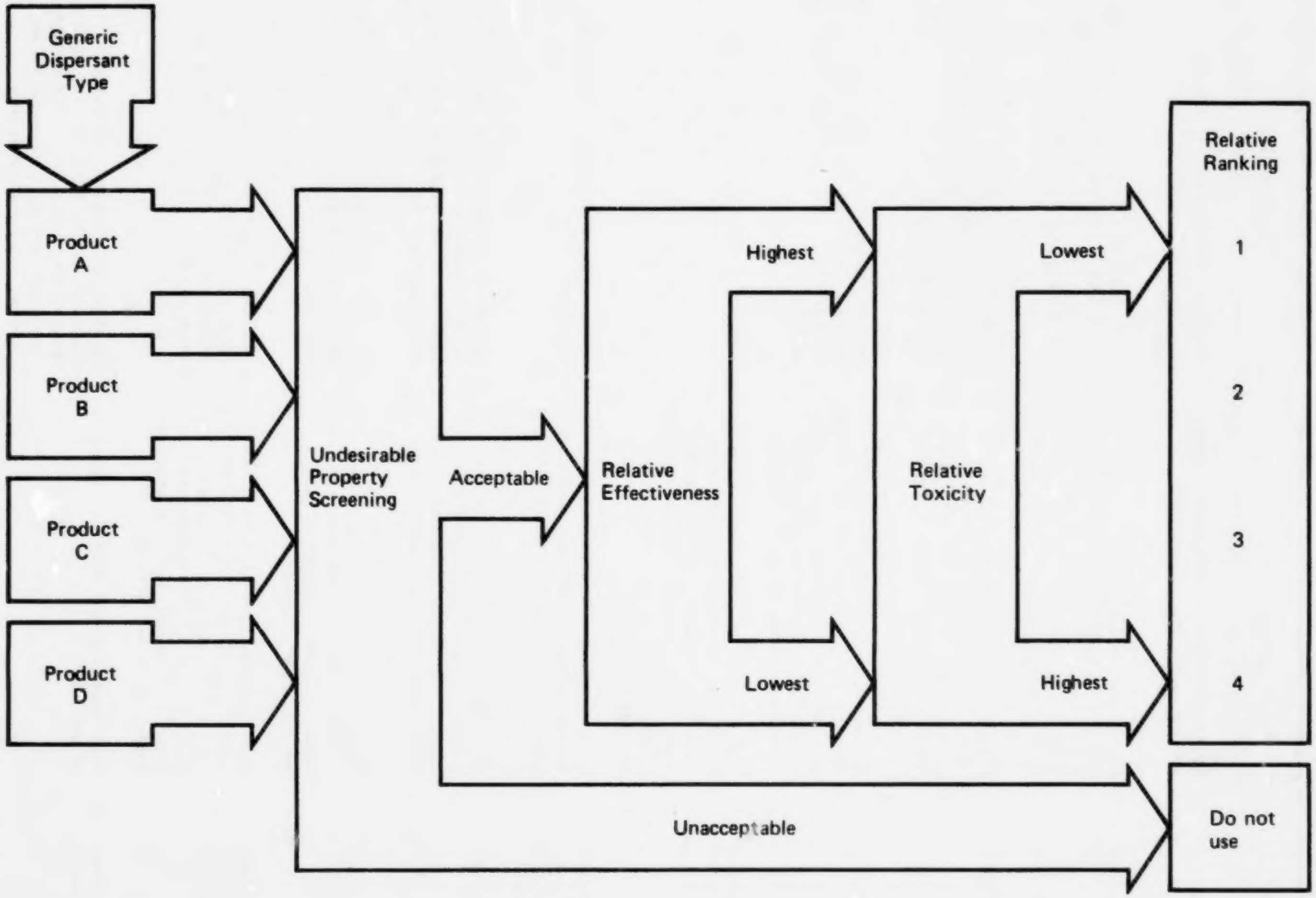


Figure 405-1. Product selection procedure.

1. OPERATIONAL PARAMETERS

Product	Special Handling	Flash Point	Pour Point	Acceptable?
A				
B				
C				
D				

2. CHEMICAL CONSTITUENTS

Product	Solvents	Additives	Metals	Chlorinated Hydrocarbons	Acceptable ?
A					
B					
C					
D					

3. EFFECTIVENESS – NO. 2 ____ NO. 6 ____ (chose closest type)

Product	Initial Relative Rank	Final Relative Rank
A		
B		
C		
D		

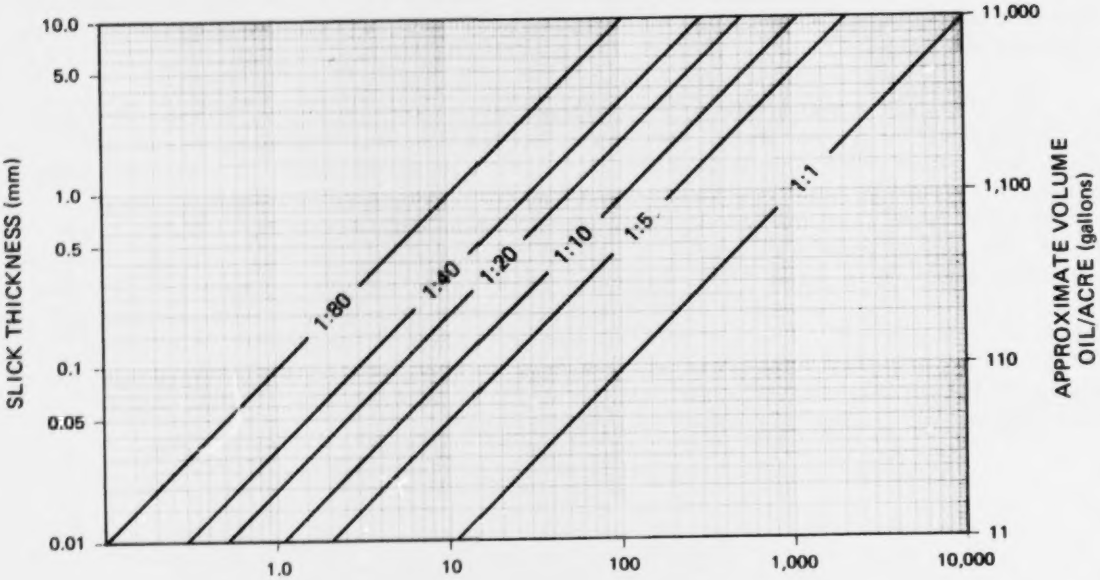
4. TOXICITY

Product	P. Promelas			F. Heteroclitus			A. Salina		
	Dispersant	Disp.+Oil	Rel. Rank	Dispersant	Disp.+Oil	Rel. Rank	Dispersant	Disp.+Oil	Rel. Rank
A									
B									
C									
D									

Figure 405-2. Product selection worksheet (using data required by Annex X).

TABLE 405-3. PRODUCT SCREENING CRITERIA

PROPERTY	EVALUATION CRITERIA	ANNEX X REF.
Special Handling or Worker Safety Requirements	Excessive special handling or worker safety precautions are undesirable	2003.3 - 4.4
Shelf Life	Age of product stock should be less than stated shelf-life (check for component fractionation, etc.)	2003.3 - 4.5
Flash Point	Flash point should not be low enough to create fire hazard or ignite if used near fire	2003.3 - 4.9
Pour Point	Pour point of product should be below ambient water temp.	2003.3 - 4.10
Heavy Metals or Chlorinated Hydrocarbons	Formulations should not contain appreciable quantities of heavy metals and/or chlorinated hydrocarbons	2003.3 - 4.17
Availability	Short-term product availability should be sufficient for initiation of use	None



(Source: SC-PCO, 1978)

Figure 405-3. Dispersant requirements at manufacturer's recommended application ratios (gallons per acre).

has been prepared to speed this calculation. To use this graph, it is necessary to estimate the approximate volume of oil per area. Using the recommended application ratio, the dispersant requirements in U.S. gallons per acre can be determined.

Example: Thickness of the slick is estimated at 0.1 mm. The manufacturer recommends his product be used at one part dispersant to 20 parts oil. Using the graph, a dosage requirement of 5 gallons per acre can be determined.

Dosage adjustment may be necessary and will require trial applications and visual assessment. In some cases multiple applications may be required to achieve the desired dosage. The lowest dosage which results in effective dispersion represents the most cost-effective and environmentally acceptable application rate.

To visually assess the effectiveness of an application, dispersion can be thought of as a two-phase process. Initially, oil and dispersant are mixed and individual droplets formed. Although technically dispersed, droplet density may be sufficient to give the appearance of an intact slick, especially if mixing energy is low. Distinguishing dispersed oil at this stage can be extremely difficult. The time required for the initial phase of dispersion may vary from instantaneous to several minutes, depending on the product and mixing energy. Nature conducts the second phase of dispersion by physically separating the treated droplets both vertically and horizontally. Oil is being rapidly dispersed when a coffee-colored cloud forms in the water column after treatment. In an effective final dispersion, little or no floating or reforming oil should be detected.

406 DISPERSED OIL MOVEMENT AND CHARACTERISTICS

Dispersed oil forms a plume in the upper water column which may or may not travel in the same direction and speed as would untreated floating oil. Since ecologic effects associated with dispersed oil and dispersant are directly related to their nature and concentration, prediction of plume movement, composition, and concentration at any point of interest is desirable. This section provides guidelines for field estimation of mixing depths in the water column, initial concentration of oil and dispersants, direction of plume movement, concentration of oil and dispersants at various points of interest, and general types of degradation which can be expected.

Evaluation of dispersed oil movement and characteristics includes:

- estimation of initial mixing depth
- estimation of initial concentrations of oil and dispersant over a specified mixing depth
- prediction of movement of the dispersed material
- estimation of maximum plume center line concentrations at any point of interest
- evaluation of probable changes in composition with time

Figure 406-1 is a worksheet for the computation of dispersed oil movements and dilution.

Estimation of Initial Mixing Depth

Dispersants and dispersed oil will mix relatively rapidly with near surface waters by turbulent diffusion and other processes. Mixing depth is controlled largely by the amount of available energy supplied by wind waves, swells, tidal currents, wind-induced currents, density currents, and artificially supplied energy (breaker boards, fire streams, propellers, etc.). Determination of "initial" mixing depth is necessary for predictive modeling of the dispersion plume and may be conducted by several methods.

Direct Observation. Mixing depths may be monitored visually in the field using divers (visibility permitting) or more precisely with field chemical measurements.

Calculation. If direct observations are not possible, initial mixing depths may be approximated from observable features such as wave height. Although no simple formulas exist for vertical diffusion and mixing processes in the ocean, the guidelines presented in Table 406-1 may be used. When using these guidelines, the greatest applicable mixing depth should be selected. Field observations suggest oil dispersed in the open ocean will remain near its initial mixing depth unless the mixing phenomenon changes.

INITIAL MIXING DEPTH

Wind Waves ____________________

Swell ____________________

Artificial ____________________

Max ____________________

INITIAL CONCENTRATION (Co)

Oil ____________________

Dispersant ____________________

SURFACE WATER MASS MOVEMENT

Direction ____________________

Speed ____________________

THREATENED AREAS

1 (Specify)__________ Dist__________ ETA__________ Cmax__________
2 __________ __________ __________ __________
3 __________ __________ __________ __________
4 __________ __________ __________ __________
5 __________ __________ __________ __________
6 __________ __________ __________ __________

Figure 406-1. Dispersed oil movement worksheet.

TABLE 406-1. ESTIMATED INITIAL MIXING DEPTHS

Situation	Mixing Mechanism	Depth Guideline
Open Ocean	Windwaves	50% of observed wave height
	Swell	10% to 25% of observed swell height
Near Shore	Mixing depth highly variable, may mix to bottom	
Artificial Mixing	Breaker Boards*	1/2 meter
	Modified Breaker Boards*	2-3 meters
	Vessel Wake and Propeller*	Propeller Depth
	Fire Stream*	1/2 Meter

*Smith, G.F. and McCracken, W.E., 1977, "Techniques for Mixing Dispersant-Treated Oil Slicks into the Water," Proceedings, 1977 Oil Spill Conference.

Estimation of Initial Concentrations of Oil and Dispersants

The initial concentration of oil and dispersant introduced into the water column can be calculated on the basis of oil thickness and dispersant applied, effectiveness of the dispersion (percent oil remaining dispersed), and the initial mixing depth. Figures 406-2, 406-3, 406-4, and 406-5 may be used to calculate concentration of dispersed oil (in parts per million) for various depths and degrees of dispersion effectiveness. To use these figures, the volume of oil present must be estimated. It may be entered in the figures as average slick thickness or as estimated oil per unit area. To reach an acceptable representation of total oil entering the water column under such circumstances, oil volume estimates should be based on averages over large areas (acres).

Dispersion effectiveness testing is among the data required by Annex X. Test data is given in terms of percent initial dispersion (after 10 minutes) and percent final dispersion (after 120 minutes) for no. 2 and no. 6 fuel oils. If used carefully, this data may be used to estimate effectiveness sufficiently to permit planning-type calculations. Effectiveness should be approximated from Annex X data (rounded to the nearest 25 percentile) for the most similar oil type. Final effectiveness values given in Annex X data are probably most representative. For any particular dispersant, final effectiveness values that are greater than the initial values suggest the continuing effect of the dispersant. Final values that are less than initial values can be associated with the resurfacing of larger oil droplets with time. Based on the mixing depth previously determined, the calculated dispersion concentration may be read directly off the figures. (Values provided by the figures do not reflect overall or component losses resulting from dissolution or other processes during weathering).

Example: Estimate the concentration of No. 6 fuel oil dispersed by product A in seas with 2 meter wave height. No supplementary mixing is used. From Table 406-1 the estimated initial mixing depth is half the wave height, or 1 meter. Test data required by Annex X for product A suggests a final effectiveness with No. 6 fuel oil of 40 percent for a dispersant/oil ratio of 1:10. Average thickness of the slick is estimated at 0.1 mm. Using Figure 406-3 (50 percent effectiveness) concentration of dispersed oil in the upper meter of water can be estimated at 50 ppm.

Estimation of dispersant concentration in near surface waters is less complicated than for oil, as dispersant application is more or less uniform. Based on an application in gallons per acre, Figure 406-6 can be used to estimate dispersant concentration at depth. For example, the dispersant concentration in the upper meter of water at an application rate of 10 gallons per acre is approximately 10 ppm.

Figures 406-7, 406-8, 406-9, and 406-10 can be used to estimate water column concentrations when dosage is given as a dispersant-to-oil ratio. For example, it is desired to estimate the dispersant concentration in the upper 3 meters for a slick averaging 0.1 mm at an application ratio of 1:20. Using Figure 406-8 the concentration can be read as approximately 1.2 ppm.

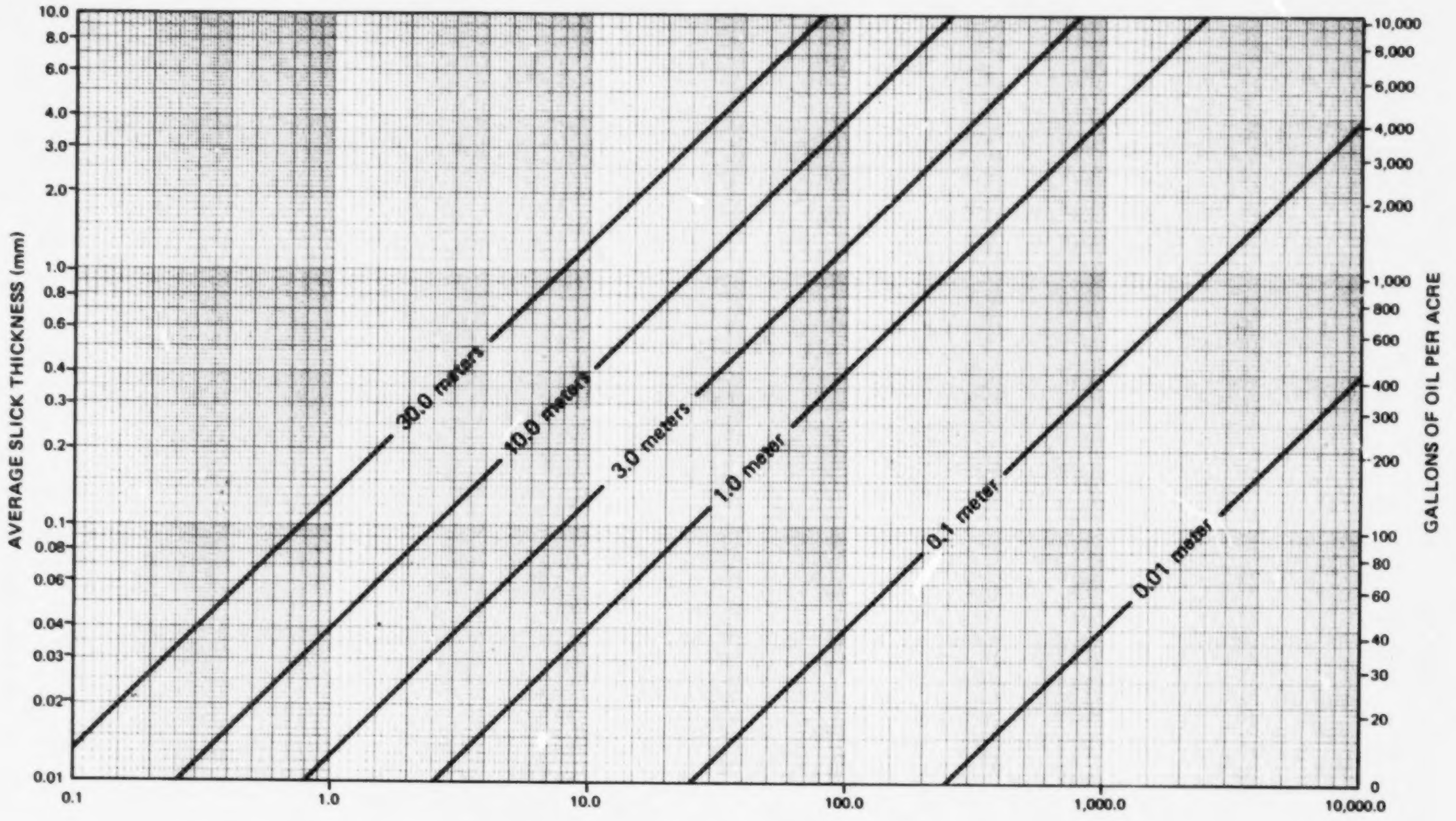


Figure 406-2. Concentration of dispersed oil at various depths at 25 percent dispersion effectiveness (ppm).

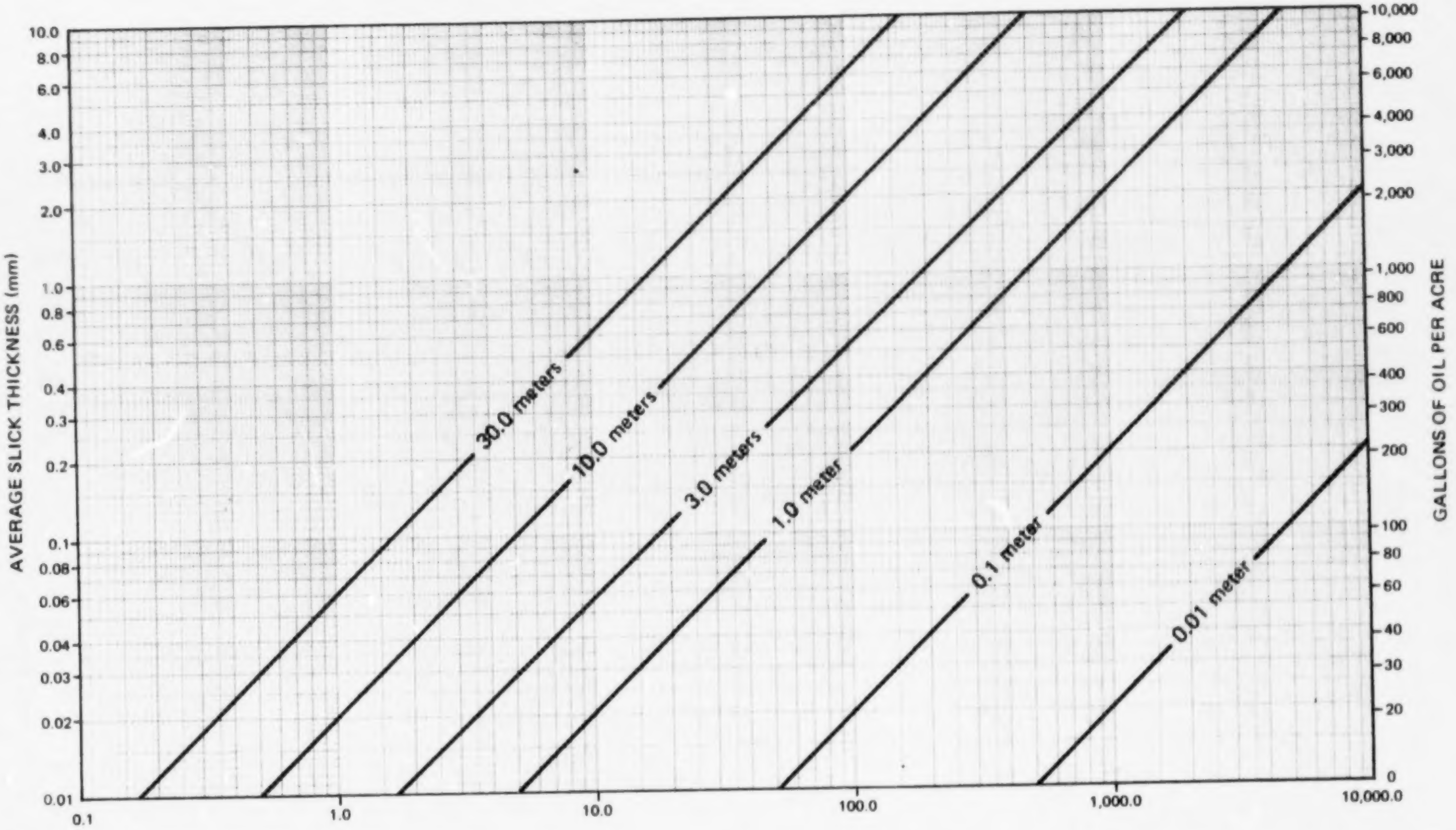


Figure 406-3. Concentration of dispersed oil at various depths at 50 percent dispersion effectiveness (ppm).

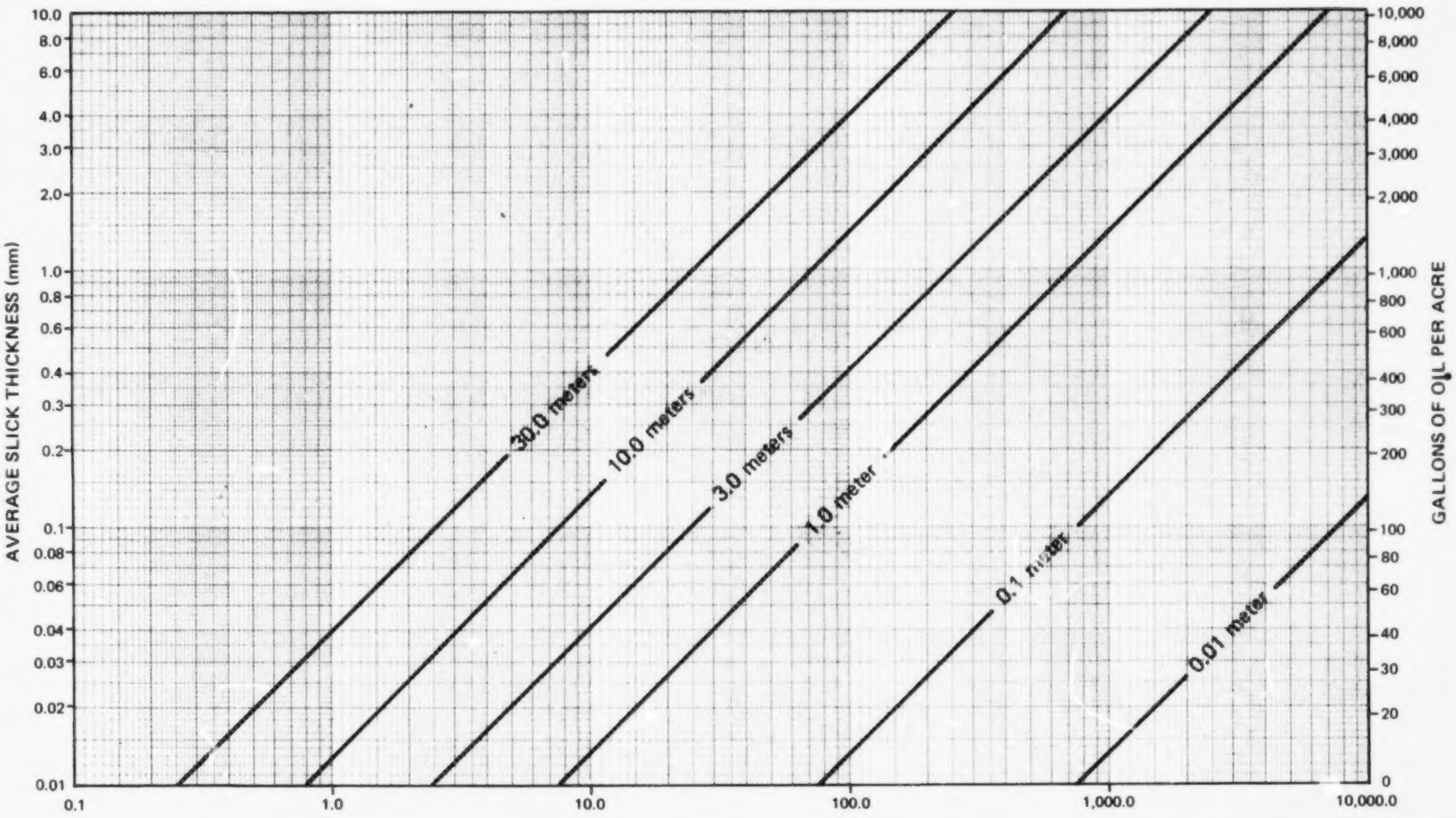


Figure 406-4. Concentration of dispersed oil at various depths at 75 percent dispersion effectiveness (ppm).

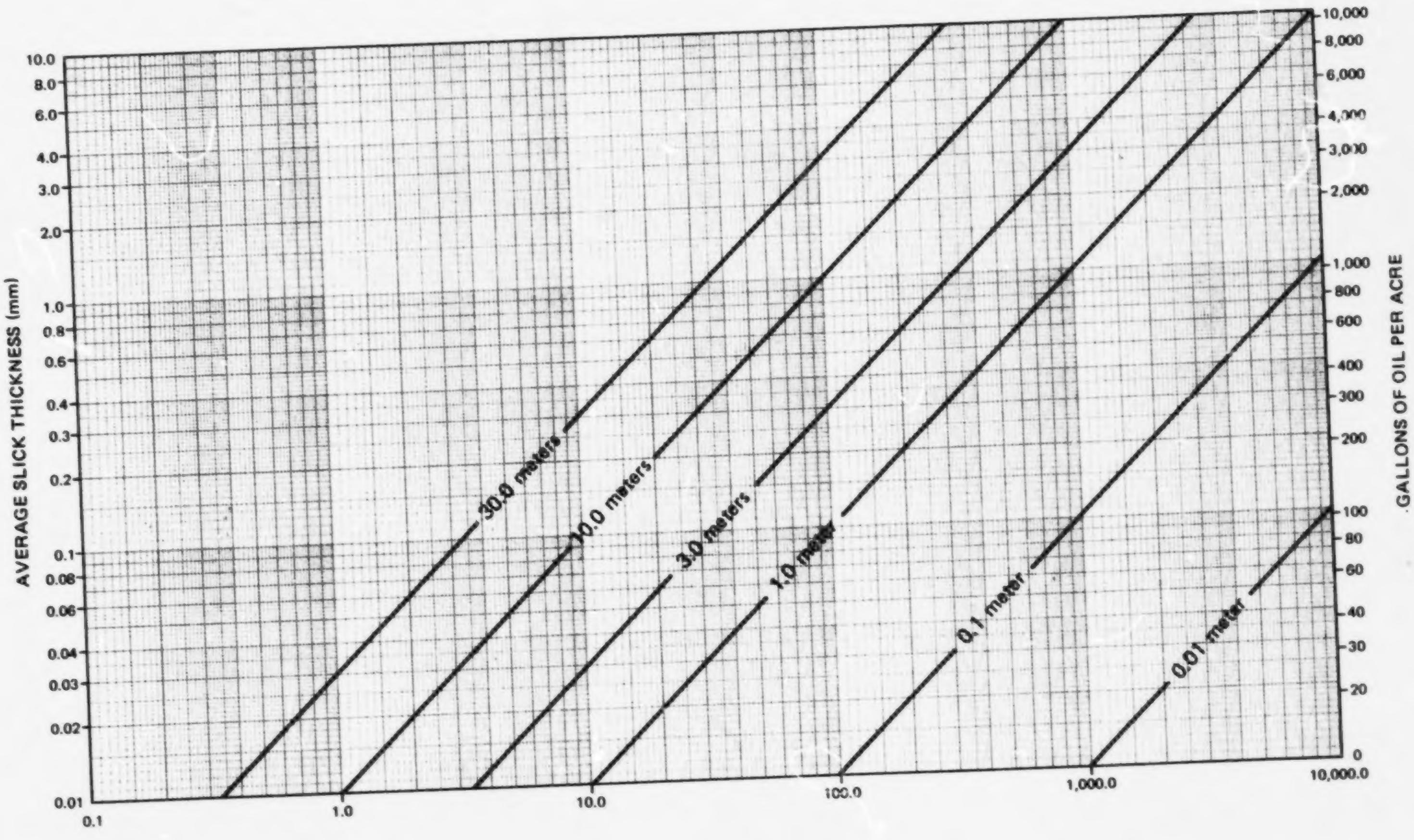


Figure 406-5. Concentration of dispersed oil at various depths at 100 percent dispersion effectiveness (ppm).

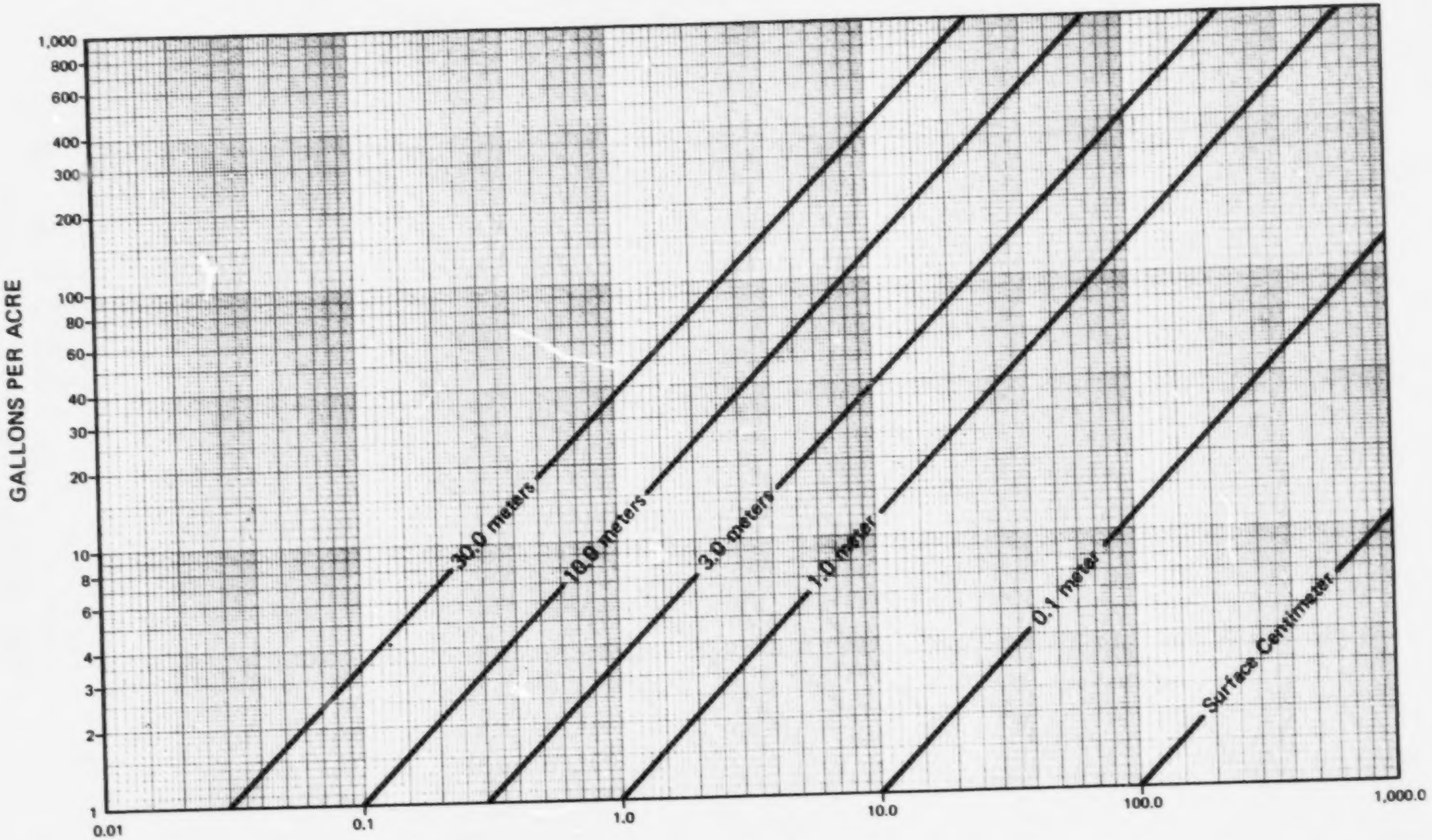


Figure 406-6. Dispersant concentration (ppm) homogeneous mixing at indicated depth.

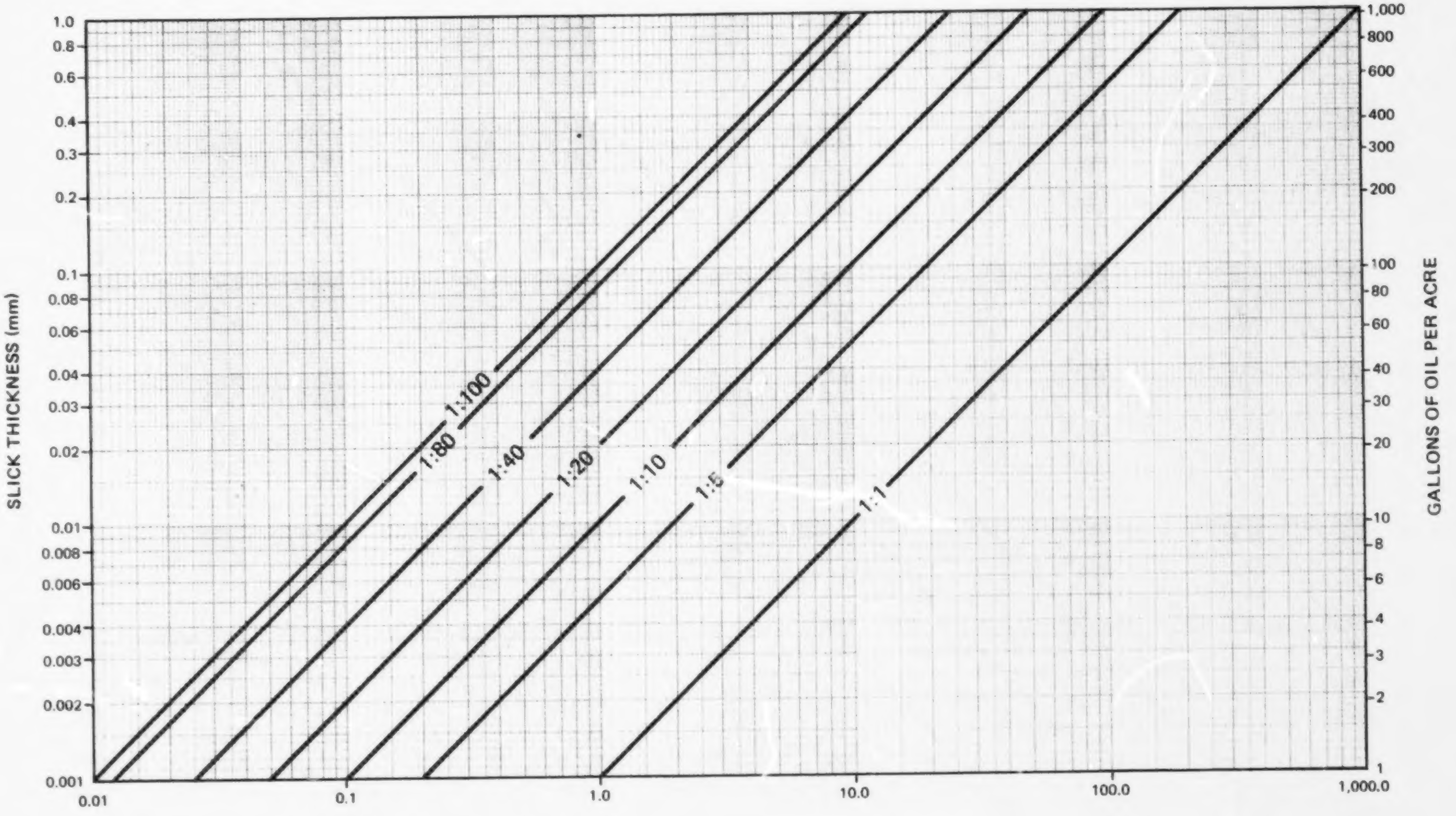


Figure 406-7. Concentrations of dispersants in upper meter for various D/O application ratios (ppm).

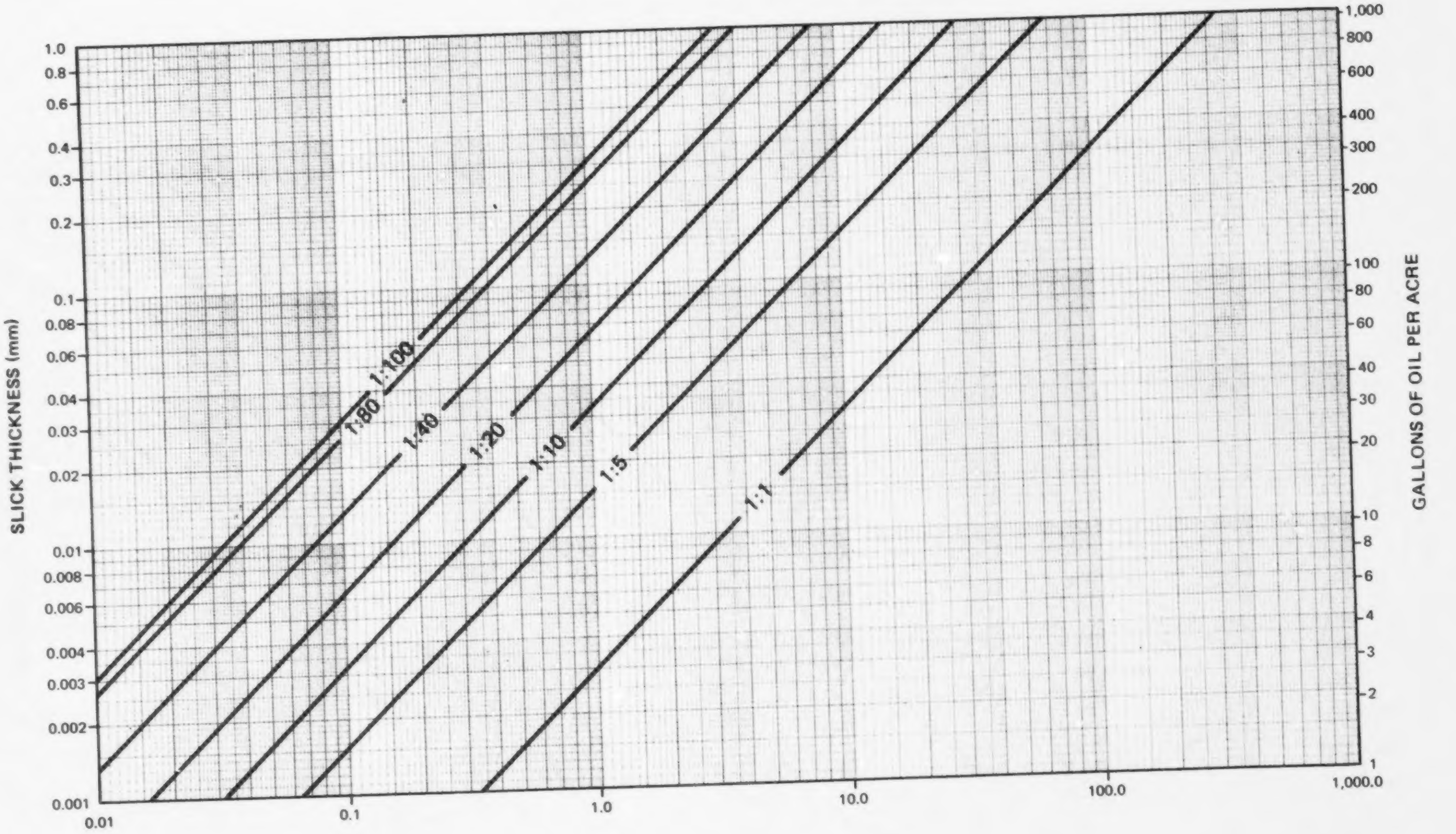


Figure 406-8. Concentrations of dispersants in upper 3 meters for various D/O application ratios (ppm).

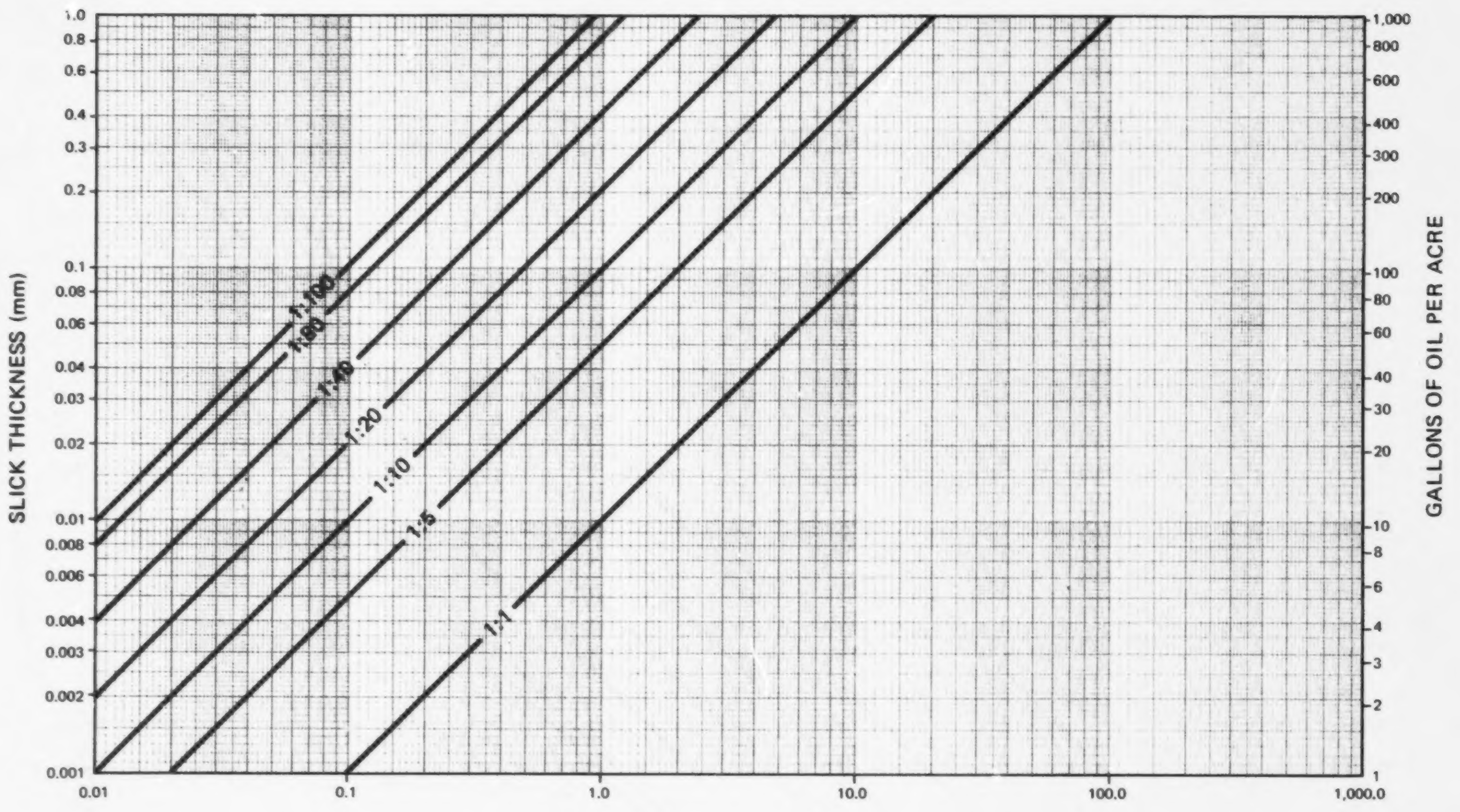


Figure 406-9. Concentrations of dispersants in upper 10 meters for various D/O application ratios (ppm).

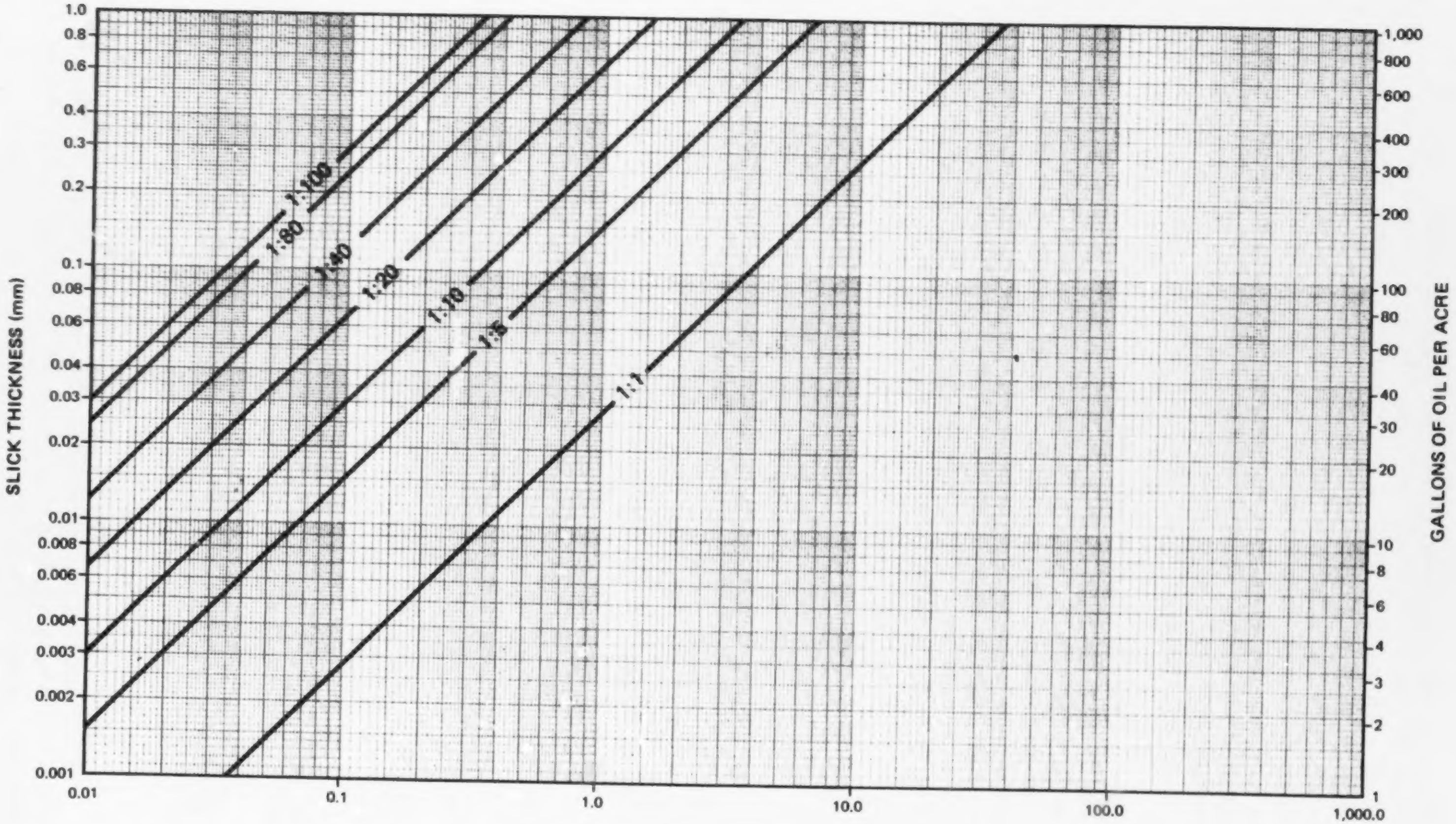


Figure 406-10. Concentrations of dispersants in upper 30 meters for various D/O application ratios (ppm).

Prediction of Movement of the Dispersed Oil and Dispersant

In most cases the movements of floating oil are dominated or strongly influenced by wind. Once dispersed into the water column, however, the effect of wind diminishes and other processes including oceanic and nearshore circulation may be more important. The direction and rate of the near surface water movement must be estimated for each situation. Sufficient hydrographic information may be available to permit estimation of movement and direction by graphic methods. If sufficient information is not available, direct field measurements of water movement such as with dye-drops and subsequent tracking or by tracking of subsurface drogues may be required.

Estimation of Plume Centerline Concentrations

Based on diffusion theory (Fickian) for surface plumes in oceanic environments, it is possible to estimate the theoretical maximum concentration of unaltered oil and dispersant at any desired downcurrent distance. Resulting concentrations will be extremely conservative in that evaporation, dissolution, and other subtractive processes cannot be directly considered due to lack of representative decay or rate constants. The basic formula* for calculation of maximum plume centerline concentration is:

$$C_{max} = C_o \operatorname{erf} \sqrt{\frac{3/2}{(1+2/3\ \beta x/b)^3-1}}$$

$$\text{where: } \beta \frac{x}{b} = \frac{12\ ax}{Ub^{2/3}}$$

with C_{max} = maximum concentration in plume at distance (x) downcurrent

C_o = initial concentration at initial mixing depth

x = distance downcurrent (cm)

b = initial plume width (width of treatment zone perpendicular to direction of movement) (cm)

U = average current velocity (cm/sec)

a = 0.01 cgs units (factor relating horizontal eddy diffusivity to lateral plume spread)

erf = standard error function which is defined as

---

*Note: The model presented is based on standard ocean outfall design practice. The objectives of the original model and properties of the materials it deals with are felt to be reasonably similar to the oil dispersion issue.

$$\operatorname{erf} x = \frac{2}{\sqrt{\Pi}} \int_{0}^{x} e^{-t^{2}} dt$$

The equation may be solved in terms of the ratio $C_{max} : C_o$ by calculating β x/b where:

$$\beta \frac{x}{b} = \frac{0.12 x}{Ub^{2/3}}$$

The equation may be solved in terms of the ratio $C_{max} : C_o$ by calculating the factor x/b and using the graph provided in Figure 406-11. Parameters used in the calculation of x/b can all be readily estimated in the field.

It is important to note that concentrations projected using this formula can be taken as maximum values. Not included in the calculation are decay factors such as evaporation, photo oxidation, biodegradation, and so on. Changes in composition due to these factors are discussed in the following section. Additionally, when applying the formula it should be kept in mind that the resulting dispersion may not be uniform. In cases where dispersion is not totally effective, the amount of oil actually dispersed in the water column can be reestimated and concentrations recalculated. In such instances, consideration must be given to assessment of the fate of the resurfaced oil. Incomplete oil dispersion should not seriously affect the calculation of dispersant concentrations in the water column.

Example: Estimate the water column concentrations of oil and dispersants where the dispersion plume is expected to encounter a shellfish bed. At the time dispersion can be implemented, the floating slick has spread to a width of approximately 1000 feet ($b = 3.05 \times 10^4$ cm). Water velocity (μ) has been measured at 0.3 knot (15 cm/sec). The shellfish bed is 20,000 ft (6.1×10^5 cm) from the dispersion line.

Using data from a previous example, initial concentrations (C_o) in the surface meter were estimated at 50 ppm dispersed oil and 10 ppm dispersant.

Therefore:

$$\beta \frac{x}{b} = \frac{0.12 x}{Ub^{2/3}} = \frac{0.12 (6.1 \times 10^5)}{15(3 \times 10^4)^{2/3}} = 5.04$$

Using Figure 406-11 the $\frac{C_{max}}{C_o}$ ratio can be determined as

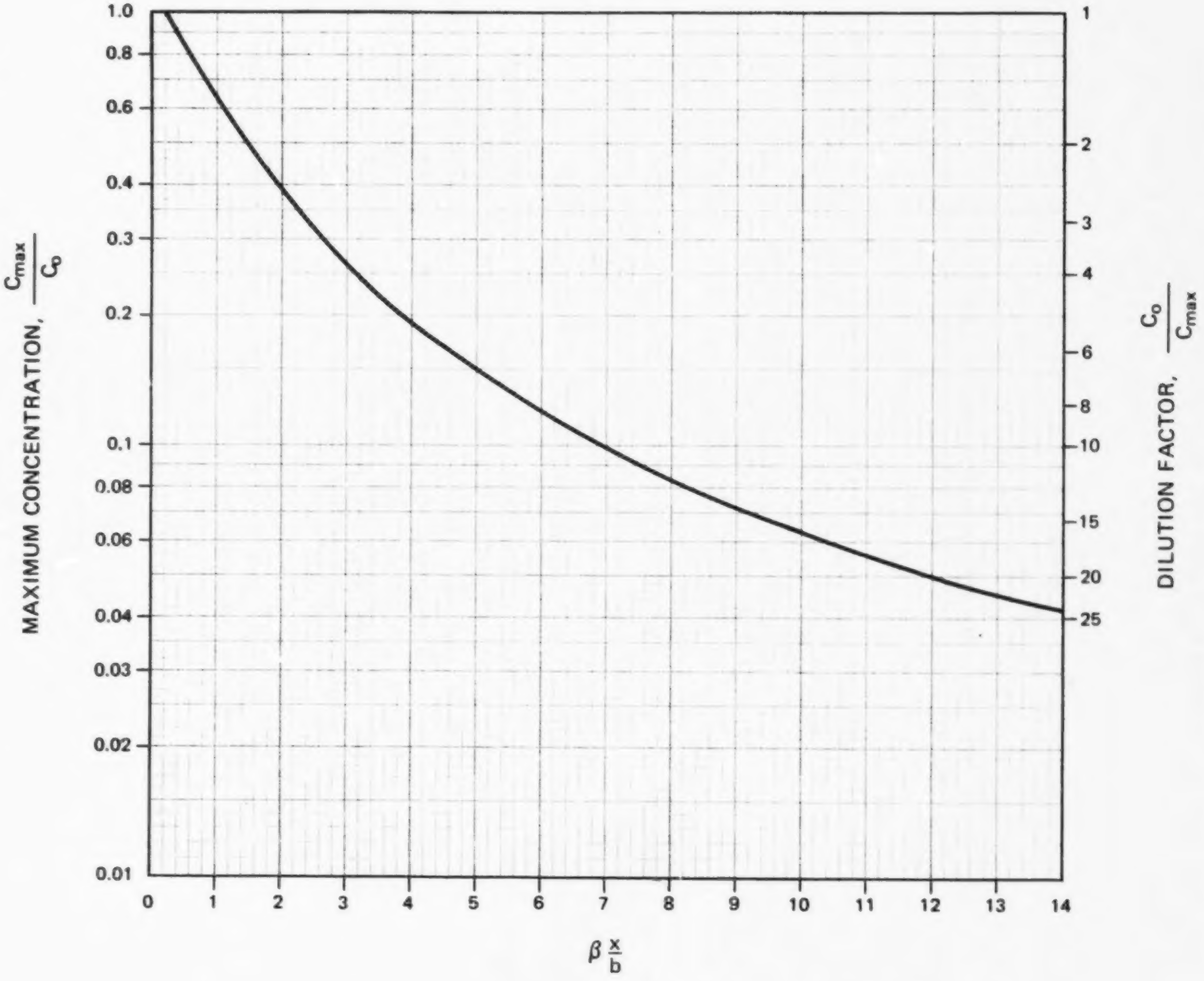


Figure 406-11. Maximum plume centerline concentration $(\frac{C_{max}}{C_o})$ as a function of $\beta \frac{x}{b}$ where $\beta \frac{x}{b} = \frac{0.12\ x}{UB^{2/3}}$ (cgs units).

0.15. Applying this ratio, maximum concentrations at the shellfish bed can be calculated as 7.5 ppm oil and 1.5 ppm dispersant.

Travel time for the plume can be calculated at about 11 hours. During this time a substantial loss of light molecular weight hydrocarbons can be expected, decreasing both the total concentration, and reducing toxic properties.

Evaluation of Changes in Composition with Time

Toxic effects are generally associated with lower weight carbon molecules (C_{14}-C_{16} and lower), most of which will dissolve or evaporate in the early hours of the spill. Evaporation will usually account for the greatest percentage of loss. Table 406-2 presents typical evaporative/dissolution losses with time and wind exposure. The data indicates most of the lighter, more toxic fractions of oil are lost within 24 hours. Field evidence suggests that dispersion can increase the naturally occurring loss rate due to evaporation and dissolution.

TABLE 406-2. TYPICAL EVAPORATION-DISSOLUTION LOSS

			PERCENT OF FRACTION REMAINING[2]								
			5 kt			10 kt			20 kt		
Fraction	Evap:Dissol.[1]	Wind Exposure	12	24	48 hrs	12	24	48 hrs	12	24	48 hrs
Paraffin (C_6-C_{14})	60:1		30	10	1	5	1	1	1	1	1
Paraffin (C_{15}-C_{22})[3]	-		97	95	89	97	95	89	97	95	89
Cyclo-Paraffin (C_5-C_{11})	12:1		25	7	1	5	1	1	1	1	1
Aromatic (Mono-cyclic) (C_6-C_{10})	6:1		20	4	1	5	1	1	1	1	1
Aromatic (Poly-cyclic)[4] (C_{10}-C_{18})	20:1		99	98	96	99	98	96	99	98	96
Residual	-		100	100	100	100	100	100	100	100	100

[1] Calculated for 10 kt wind

[2] These values are approximate and dependent on factors including temperature, oil film thickness, emulsification, etc.

[3] Estimated time for 10 percent remaining is 40 days

[4] Estimated time for 10 percent remaining is 110 days

SOURCE: James et al. (1972)

407 IMPACT COMPARISON

General Procedure

Oil spill response decisions should aim for the minimum probable environmental damage whether chemical dispersion is used or not. This section provides a means for identifying amenities threatened by various actions and assessing their probable impacts. It also provides onscene criteria for weighting resulting impacts. Evaluations may be conducted for the entire spill or for specific geographic areas of a large incident. Impacts can be evaluated and compared using the following steps:

A. Using information provided in Sections 302, 402, and 406, list the amenities threatened by both conventionally or nontreated oil, and by chemically treated oil.

B. Assess the probable severity of each type of impact for both conventionally or non-treated and chemically treated cases for each amenity as appropriate.

C. Weigh the impacts and identify the case resulting in the least probable impact for the situation.

Note: When conducting the assessment and comparison, it is important to remember that chemical treatment will likely not be 100 percent effective. Oil not dispersed in the upper water column at the point of contact with the threatened amenity may react as untreated oil and require assessment in both categories.

Impact Comparison Matrix

Figure 407-1 provides a matrix to be used in organizing the impact assessment and comparison. Before using the matrix, predicted movement and extent of untreated and dispersed oil (as determined in Section 302 and 406) should be plotted on appropriate charts. In consultation with local representatives, amenities of concern within both zones of exposure should be identified (Section 402) and listed in the threatened amenity column of the matrix. The general types of impacts can then be assessed. Three levels of impact should be considered: probable severe impact; unknown impact; and probable low impact. More specific guidelines for defining a "probably severe" impact to an amenity are given in Table 407-1.

Where the extent of possible contamination is uncertain, evaluations should assume a worst-case situation. Subjective judgements about non-biological impacts are relatively straightforward and self-explanatory. Biological questions are more complex. The following discussion will help the user assess "biological" questions related to treated and untreated cases.

The Chemically Treated Case

Extensive information exists regarding the toxic effects of oil and dispersants but this information must be used with caution in regard to direct field application. Laboratory tests and field observations regarding the effects and performance of the high toxicity Torrey-Canyon era dispersants

	IMPACTS													
	CONVENTIONALLY OR NOT TREATED							CHEMICALLY TREATED						
THREATENED AMENITY	economic	aesthetic	toxicity	smothering	sublethal	persistence	recovery	economic	aesthetic	toxicity	smothering	sublethal	persistence	recovery

+ = Probable severe impact
0 = Unknown impact
– = No or probable low impact

Figure 407-1. Impact comparison matrix.

TABLE 407-1. CRITERIA FOR "SEVERE" IMPACT RATING

IMPACT CATEGORY	SEVERE RATING CRITERIA
ECONOMIC	If the temporary or long-term loss of an amenity will affect the local or regional economy directly (e.g., closing of commercial fishing grounds) or indirectly (e.g., decreased tourism because of contaminated recreational beaches), then the the particular action is considered to have a "probable severe impact" on the amenity.
AESTHETIC	If the temporary or longer-term presence of oil will change the esthetic value of an amenity, and especially if the amenity is valued in part because of its appearance (e.g., oil on sailboat hulls, oil on a recreational beach), then the particular action is considered to have a "probable severe impact" on that amenity.
TOXICITY	If the presence of oil, dispersant, or dispersion, through the action of its chemical properties, will adversely affect a major portion of a biological amenity (e.g., a commercial shellfish bed) then the particular action is considered to have a "probable severe impact" on that amenity.
SMOTHERING	If the oil will adversely affect a major portion of a biological amenity through the action of physical contact (i.e., smoothering, covering, clogging, suffocating) then the particular action is considered to have a "probable severe impact" on that amenity.
SUBLETHAL	Oil, dispersant, or components thereof will interfere with a significant portion of a population or community at a sublethal level. Interferences can include disruption of reproductive or other functions, carcinogen effects, and so on.
PERSISTENCE	If contamination by oil, dispersant, or dispersion will result in the incorporation of oil and/or toxic substances in the environment (e.g., burial on a beach) such that they become a long-term fixture of that environment, then the particular action is considered to have a "probable severe impact" on that amenity.
RECOVERY	If the temporary or longer-term presence of oil, dispersants, or dispersions will physically or chemically delay or prevent the recovery of the amenity to pre-spill conditions, then the particular action is considered to have a "probable severe impact" on that amenity.

are not germane to, nor should be used in the assessment of modern, low toxicity products. Data on modern dispersants are difficult to compare due to the considerable variability in test oils, procedures, test organisms, and duration of exposure, and can seldom be compared or applied directly to the field. Test data required by Annex X does provide a measure of uniformity and, while not directly applicable to field use, may be used to rank products. Toxicity rankings should be used in terms of order(s) of magnitude differences and not absolute values. In the broadest sense, the joint IMCO/FAO/UNESCO/WMO Committee (1969) proposed grades of toxicity for pollutants in the aquatic environment can be used to indicate how order of magnitude differences relate in scale (Table 407-2). Grades proposed by other experts are also shown in this table.

After identifying lower toxicity dispersants using the EPA toxicity data, estimates of dispersant and oil concentrations in the water column, as described in Section 406, can be used for predicting potential ecological effects. Although no field-worthy models exist for predicting the ecological effects associated with a given concentration of oil or dispersant, approximate toxic concentration limits for each dispersant product and each generic oil type can be delineated by relating estimated dispersant concentrations with EPA LC data for approved dispersants (an LC_{50} is the concentration at which 50 percent of the test organisms do not survive over a given time period). Figure 407-2 (impact severity chart) can then be used to estimate the impact severity a particular dispersant could have on a particular biological amenity. The figure should be used in the following manner:

1) Obtain the most sensitive LC_{50} from the EPA data for the proposed dispersant(s) (i.e., use the lowest ppm LC_{50} of the three bioassays).

2) Find the LC_{50} value on the vertical axis of the figure and draw a horizontal line from that point.

3) Obtain the estimated concentration of the dispersant or oil/dispersant at the desired location from Section 406.

4) Find the dispersant concentration on the horizontal axis (for the appropriate safety factor) and draw a vertical line from that point.

5) If the two lines intersect above the diagonal line, the dispersant can be expected to have "probable low impact" on the biological amenity. If the two lines intersect below the diagonal line, the dispersant can be expected to have a "probable severe impact" on that amenity.

Three safety factors are incorporated in the horizontal axis of the chart. In 1972, the NAS-NAE Committee on Water Quality proposed that "the prediction of safe levels be made by carrying out bioassays for acute lethal toxicity and multiplying the lethal concentration by a suitable application factor." The committee recommended that the maximum concentration not exceed

TABLE 407-2. GRADES OF TOXICITY

	TLm(mg/1)[1]	LC_{50}(ppm)[2]	LC_{50}(ppm)[3]
Practically non-toxic	>10,000	10,000-1,000,000	
Slightly toxic	1,000-10,000	1,000-10,000	>10,000
Moderately toxic	100-1,000	100-1,000	1000-10,000
Toxic	1-100	10-100	100-1000
Very Toxic	1	10	100

[1] IMCO/FAO/UNESCO/WMO Group of Experts (1970).
[2] Jeffery, P.G., and J.A. Nichols (1974).
[3] Beynon and Cowell (1974)

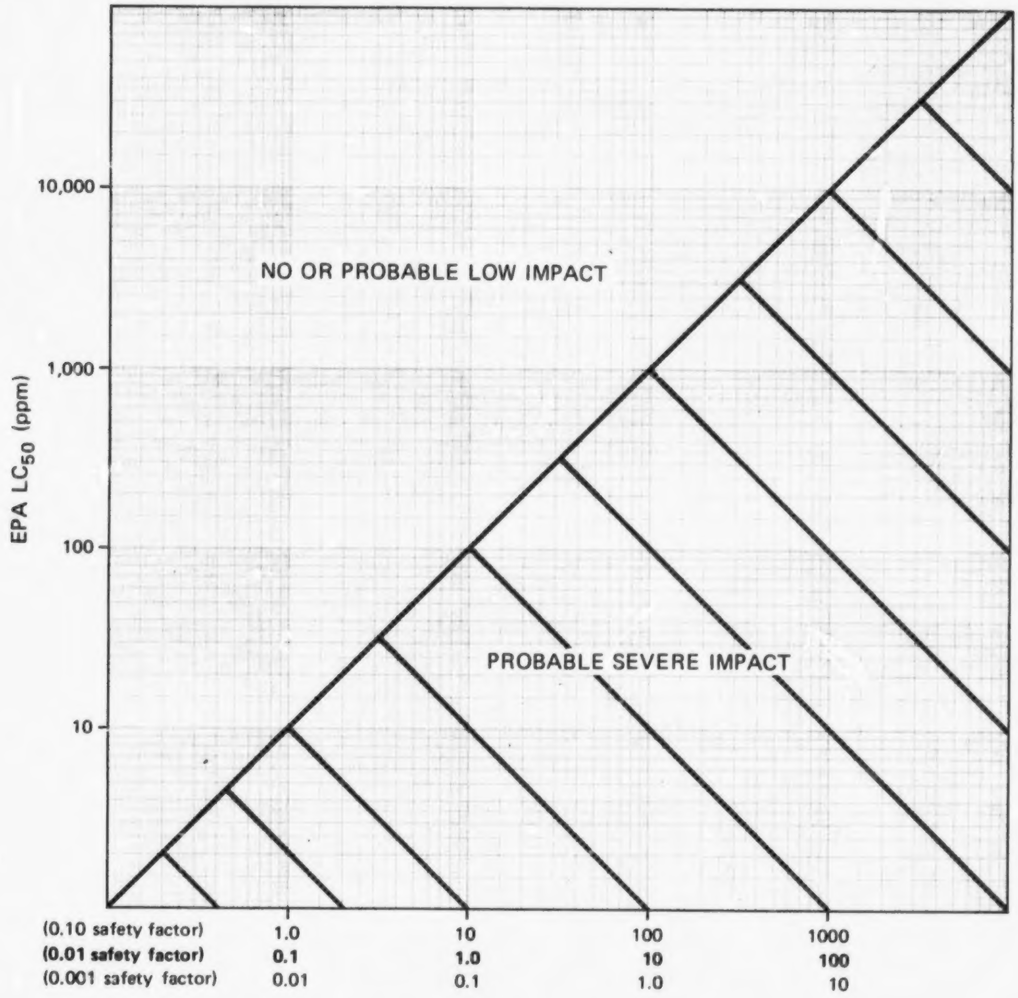


Figure 407-2. Impact severity chart.

one one-hundredth (0.01) of the LC_{50} values. This 0.01 factor is intended for application to single species, and is subject to some question when applied to ecosystems whose component members may exhibit varying levels of toxic response. The accuracy of the resulting impact prediction improves if the procedure is used on a number of local species. When only EPA test data are available the resulting predictions should provide a general indication of overall impact. For highly sensitive situations demanding additional precaution, a 0.001 safety factor (one one-thousandth of the LC_{50}) can be applied; for less sensitive situations, concentrations using a 0.1 safety factor (one tenth of the LC_{50}) can be used. Selection of the appropriate factor is at the discretion of the OSC in consultation with his support staff and local scientists.

Exposure time is another important consideration. Typically, the longer an organism or aquatic community is exposed to a given concentration, the higher the potential for adverse impacts. In using Figure 407-2, it is assumed that organisms will be exposed indefinitely. In reality, concentrations actually encountered likely to be short-term phenomena owing to natural mixing and rapid dilution phenomena. EPA LC_{50} bioassays are run for 48 or 96 hours, depending upon the test organisms and concentration is not diluted over time. The use of the most sensitive (lowest ppm) of the three bioassay tests for the dispersant's base LC_{50} skews the outcome toward the "probably severe impact" designation.

Example: A valuable shellfish bed lies 3 m deep and 2 km from the proposed dispersion point. The estimated concentration of dispersant at the bed is calculated at 2 ppm, and EPA toxicity data shows the lowest LC_{50} concentration for this dispersant to be 2500 ppm. Using Figure 407-2 the point where 2500 ppm and 2 ppm intersect (using the 0.01 safety factor) is clearly in the "probable low impact" area. Thus, the specified dose of this dispersant should not acutely affect the shellfish bed. If the most sensitive LC_{50} for the dispersant had been 100 ppm instead of 2500 ppm, the conservative prediction would have been different (i.e., the dispersant should have a probable severe impact).

Multiple Dispersant Applications and Maximum Permissible Dosage. Figure 407-2, can also be used to estimate safe maximum concentrations for multiple dispersant applications or the permissible maximum concentration for a given LC_{50} toxicity. The maximum allowable (sublethal) concentration of dispersant in the water column is divided by the anticipated concentration from each application to determine the number of applications that can be safely undertaken. This number will be quite conservative in areas with high circulation rates as continual dilution will preclude the buildup of high dispersant concentrations. Under no circumstances should the indicated maximum acceptable concentration be exceeded.

Dispersed Oil Effects

After determining the potential effects of the dispersant, the potential effects of the dispersed oil must be evaluated. Unlike dispersants, no standardized toxicity test for oil exists, as the composition of oils and refined products vary widely. Should the user have access to toxicity data for an oil similar to the one spilled, Figure 407-2 can be used to predict the severity of the potential impact in a fashion similar to one for dispersants. Again, use of the 0.01 safety factor and the assumption that all the toxic components of the oil are transferred into the water column (when, in fact, the more volatile fractions are usually quickly lost through evaporation) should ensure an adequately conservative outcome. If no oil toxicity data are available, background information on the effects associated with generic oil types and past spill events (as discussed for the untreated case) will have to be used in making assessments.

Some laboratory and field evidence suggests that chemically produced oil dispersions may be more toxic than naturally produced dispersions. It has been hypothesized that this phenomena is a synergism between oil and dispersant which produces more toxic end products. The "increased toxicity" of a dispersion is probably more related to the increased availability of the oil to marine organisms. By breaking the oil up into minute droplets, the dispersant enhances the uptake and incorporation of certain oil components by many marine organisms through their breathing and feeding mechanisms. For this reason, dispersed oil may have a more adverse impact on a biological amenity than untreated oil at the same concentration.

This differential could be extremely important in relation to the incorporation of certain polycyclic aromatic hydrocarbons and complex hydrocarbons and tars into edible fish and shellfish as they may result in tainting. In addition, these substances have been implicated as possible carcinogens though the dose/response relationships for both large, single-dose exposures and low-level, chronic exposures to such carcinogens are far from resolved.

The breakdown of oil into fine droplets has some environmental advantages which may outweigh its possible drawbacks. By increasing the surface area exposed per unit volume of oil, biodegradation is accelerated thus decreasing persistence in the marine environment. Similarly, the dispersant, by coating the oil droplets may prevent the oil from sticking to plant, rock, and sediment substrates.

Little information is available regarding sublethal long-term effects of dispersed oil. Chronic low-level exposure could occur if oil or dispersant is incorporated into sediments and gradually released with time. This is most likely to occur in estuaries and near-shore environments. Sublethal concentrations and effects are difficult to detect and measure in the environment. Such sublethal effects include possible change in fecundity, fertilization, larval development, respiratory rate, and escape and feeding responses. Recognizing the possible consequences in a population or marine community, some researchers have proposed that standard toxicity tests should measure the lowest median concentrations that affect biological functions important for survival of individuals in an ecosystem. Many modern dispersants are, however, biodegradable and should not create chronic toxicity problems. Until better information is available prediction of biological effects expected with dispersants, dispersions, and untreated oil must be dictated by lethal concentration considerations and prudent use of safety factors.

The Untreated Case

The deleterious effects of untreated oil on marine life are largely due to physical rather than chemical action [i.e., interference of respiration through clogging (smothering) of gill filaments versus physiological effects of uptake of toxic components]. Although certain components of oil are extremely toxic, the smothering and mechanical interference of biological activity often cause greater damage.

Low-boiling aromatics and saturated hydrocarbons (e.g., in light fuel oils) appear to be more directly toxic than the higher-boiling saturated hydrocarbons (e.g., in heavy crudes). Typically, those fractions with low boiling points are lost first. Table 407-3 gives the estimated concentrations (ppm) of the soluble aromatics required to cause toxicity in various classes of organisms and the amount of No. 2 fuel oil and a representative crude oil needed to produce an equivalent dose of aromatics. It is apparent from the table that No. 2 fuel oil owes its high toxicity to its high aromatic content. Larval forms are more susceptible to impact than are the adults of the same species. In the case of an offshore spill moving onshore, chemically toxic, unweathered oil may never come into contact with marine organisms other than plankton populations in the immediate spill vicinity.

Tainting and the accumulation of potentially carcinogenic agents in commercial fish and shellfish can and do occur with an untreated oil slick through natural dispersion, solubilization, and long-term persistence. The higher molecular weight polynuclear fractions in oil may be particularly significant in their persistence and subsequent accumulation in the food web, although many of the edible fish and shellfish species depurate (or eliminate) the petroleum hydrocarbons that they accumulate when no longer exposed to contamination.

When a weathered oil does reach the nearshore area, massive mortalities can result. The most visible class of organisms affected are usually birds, particularly those species that feed by diving. Oil penetrates and clings to the plumage, matting the feather structure and causing loss of insulative properties. The bird can then become chilled and susceptible to severe metabolic stress, exhaustion, and disease. In addition, an oiled bird can ingest quantities of oil during preening which can cause poisoning, inflammation of the digestive tract, or disturbance of other physiological processes. Oil can also have a profound direct effect on the viability of bird eggs and on the capability for incubation of fertile eggs if the breasts of nesting birds are contaminated.

Invertebrate populations may suffer dramatically when in physical contact with the oil. Recruitment and recovery can be rapid if the affected organisms represent only a portion of a larger, regional population and the oil does not persist. Successional recovery of an intertidal marine community ranges from weeks or months to a decade, depending on the structural complexity of the community, the amount and type of oil present, the persistence of the oil, and the degree of the initial damage. Persistent contamination by petroleum, or frequent chronic spills, may hinder natural succession and slow recovery.

TABLE 407-3 SUMMARY OF TOXICITY DATA

	Estimated Concentration (ppm) of Soluble Aromatics Causing Toxicity	Estimated Amount (ppm) of Petroleum Substances Containing Equivalent Amount of Aromatics	
CLASS OF ORGANISMS		#2 FUEL OIL	FRESH CRUDE
FLORA	10 - 100	50 - 500	$10^4 - 10^5$
FINFISH	5 - 50	25 - 250	$10^4 - 10^5$
LARVAE (All species)	0.1 - 1.0	0.5 - 5	$10^2 - 10^3$
PELAGIC CRUSTACEANS	1 - 10	5 - 50	$10^3 - 10^4$
GASTROPODS (Snails, etc.)	10 - 100	50 - 500	$10^4 - 10^5$
BIVALVES (Oysters, clams, etc.)	5 - 50	25 - 250	$10^4 - 10^5$
BENTHIC CRUSTACEANS (Lobsters, crabs, etc.)	1 - 10	5 - 50	$10^3 - 10^4$
OTHER BENTHIC INVERTEBRATES (Worms, etc.)	1 - 10	5 - 50	$10^3 - 10^4$

Stephen Moore. 1973. Background Papers for a Workshop on Inputs, Fates, and Effects of Petroleum in the Marine Environment. National Academy of Sciences.

Comparing Impacts

The completed comparison matrix forms a basis for determining the most acceptable overall mode of treatment. The individual impact cells of the matrix are not additive and therefore the most appropriate action will not necessarily be the one with the least number of severe impacts. The matrix has been designed as a qualitative rather than a quantitative tool because different amenities can have dramatically different values at different times of the year and in different local and regional settings. For example, a waterfowl feeding area along a coast may be considered more valuable during a winter spill when large numbers of birds are present than would a recreational swimming area that is used almost exclusively in summer. Their relative standing might be reversed during a summer spill depending on the type and expected persistence of the oil, relative recovery times for both the waterfowl feeding and swimming areas, and the availability of similar areas outside the zone of contamination. Conceivably a local or regional community that depends solely on tourism for its livelihood would consider a single severe impact to their recreational beaches more important than a combination of other types of impacts.

The purpose of the matrix is to ensure that the major potential effects of each action are considered. In consultation with local and regional experts, the user must compare the different weightings of the amenities in determining the most acceptable alternative.

Example: A crude oil spill occurs in coastal waters and threatens to move into an area characterized by the special features and amenities as identified by the OSC and listed in Figure 407-3. Environmental conditions preclude conventional control actions in all areas with the exception of the larger estuary. Even in this area the adequacy of any conventional effort is uncertain. Considering the sensitive nature of the shoreline, it is decided to evaluate the feasibility of chemical dispersion offshore to reduce the overall damage. Estimated zones of contamination are calculated using procedures presented earlier in this manual. The results are shown in Figure 407-3.

With the assistance of local and regional experts, evaluations of the impact severity on each amenity are conducted. The results are listed on the comparison matrix shown in Figure 407-4. As indicated, "probable severe impacts" can be expected with oiling of all threatened shoreline amenities. Chemical dispersion is an attractive alternative because it may reduce or eliminate contamination of these areas. Plume dispersion modeling suggests that an important commercial shellfishing area lies in the path of the dispersed oil plume, and that the concentration of dispersant in the waters over the shellfish bed may reach 1.5 ppm. Toxicity data on the dispersant used include a lowest LC_{50} of 1000 ppm. Using Figure 407-2 a "probable low impact rating" is determined using a 0.01 application factor. The concentration of dispersed oil at the shellfish area has been previously estimated at 100 ppm. Travel time has been previously estimated at 20 hours,

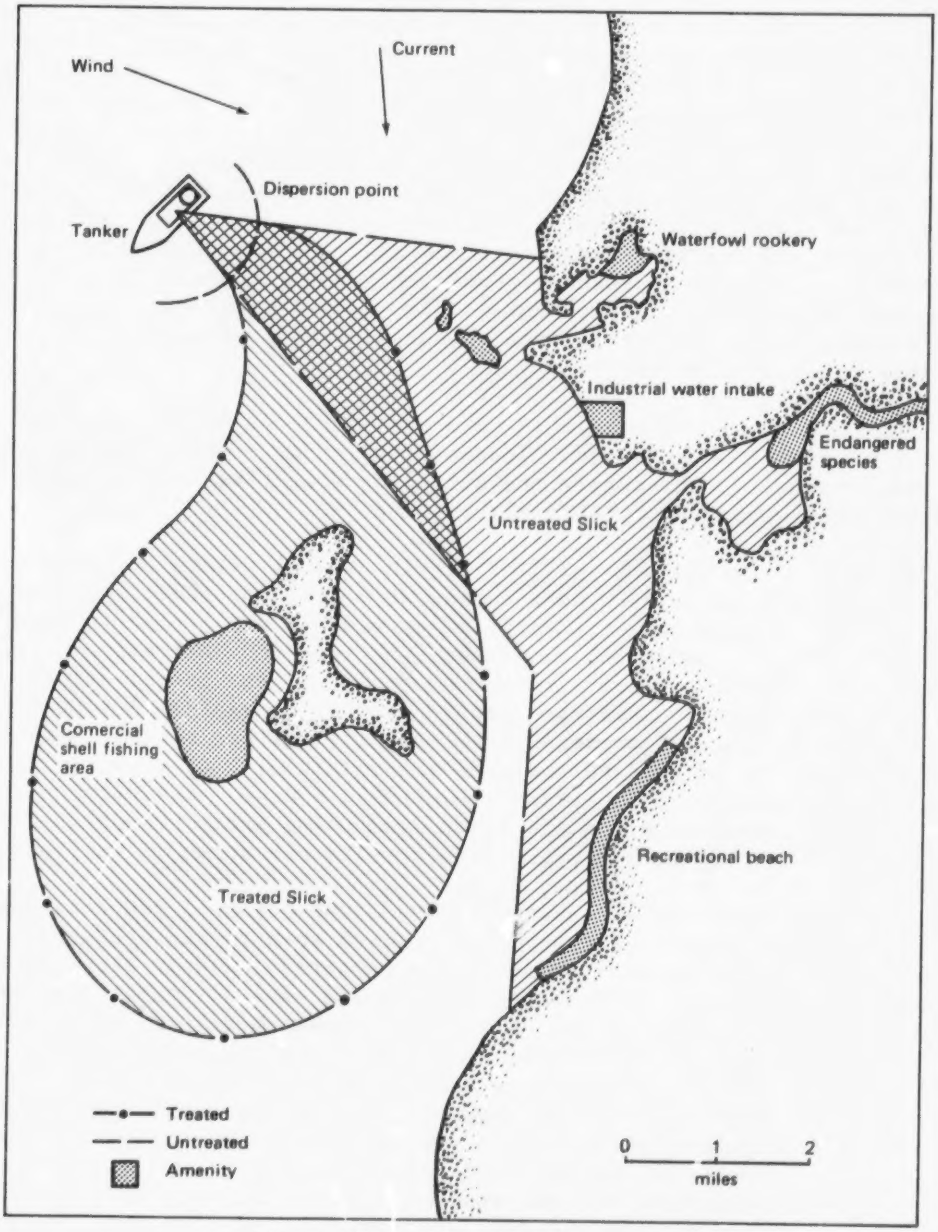


Figure 407-3. Hypothetical spill event.

THREATENED AMENITY	IMPACTS													
	CONVENTIONALLY OR NOT TREATED							CHEMICALLY TREATED						
	economic	aesthetic	toxicity	smothering	sublethal effects	persistence	recovery	economic	aesthetic	toxicity	smothering	sublethal	persistence	recovery
Waterfowl rookery	–	+	0	+	0	–	0							
Industrial water intake	+	–	–	–	–	–	–							
Endangered species	–	–	+	0	0	0	+							
Recreational beach	+	+	–	–	–	–	–	0	–	–	–	–	–	–
Commercial shellfishing area								–	–	–	–	0	–	0

+ = Probable severe impact
0 = Unknown impact
– = No or probable low impact

Figure 407-4. Hypothetical spill event impact comparison matrix.

sufficient to allow significant reduction in this concentration through loss of volatile fractions. In addition, the calculations consider only the upper several meters; the shellfish beds are at a depth of 60 meters. Thus, risks to the amenity appear far less than the probable effects of untreated oil impact on the amenity shoreline. Chemical treatment is recomended at the indicated site.

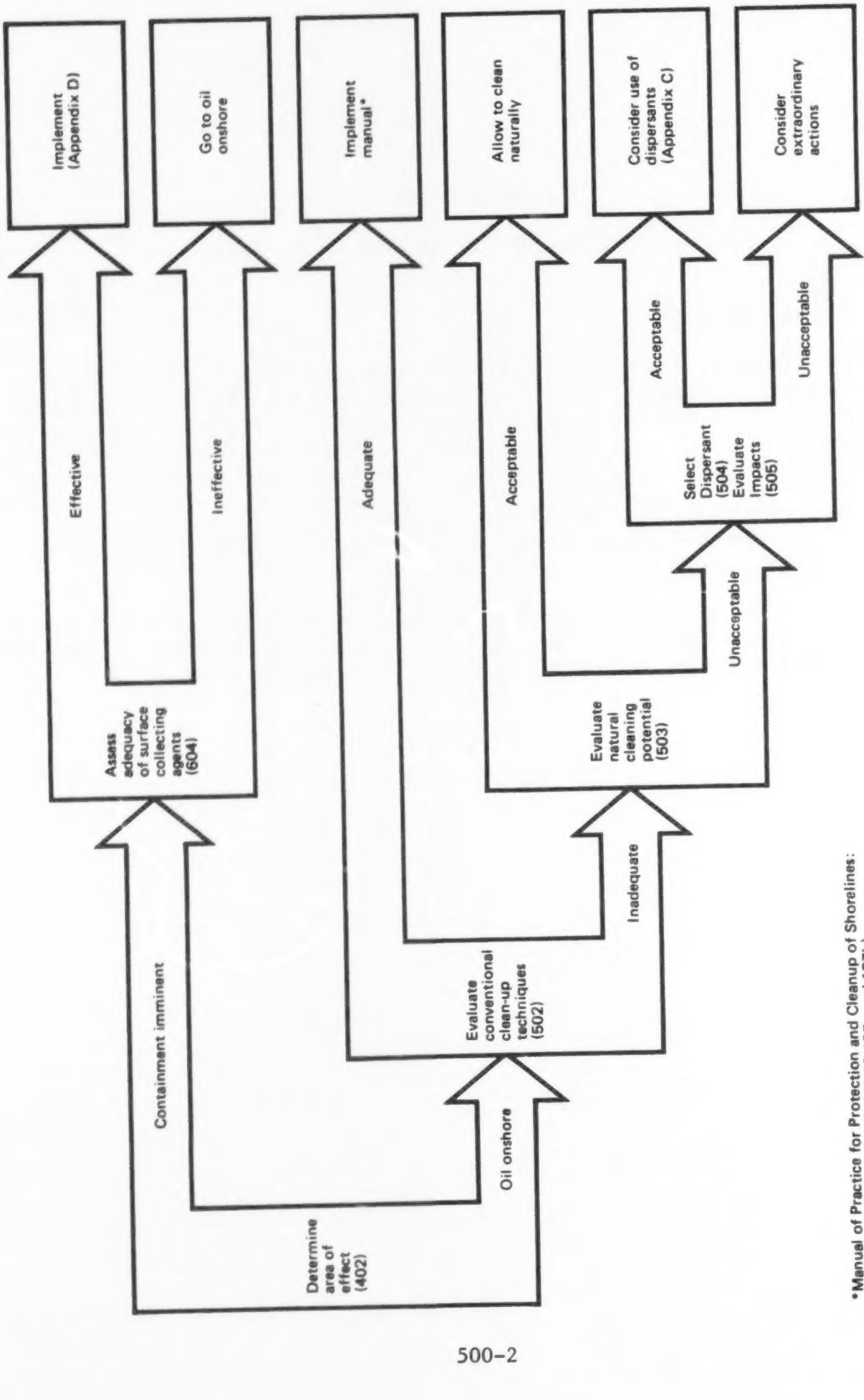
SECTION 500

CRITERIA FOR USE OF DISPERSANTS ON SHORELINES

501 GENERAL PROCEDURE

Dispersants can aid in the restoration of shorelines by loosening or dissolving oil coatings or preventing the adherence of physically loosened oil particles on other surfaces. Due to difficulties in controlling dosage and the potential for environmental side effects, dispersants should only be considered for cleaning contaminated shorelines when mechanical cleanup and natural recovery are judged very difficult, ineffective, or potentially more environmentally damaging. To consider products for shoreline use, they should be recommended for that purpose or designated as beach-cleaners by their manufacturers.

Figure 501-1 gives a sequence of considerations required to evaluate the probable acceptability of dispersant use for shoreline cleaning. Supporting sections of the manual have been referenced when appropriate.


Determine area of effect (402)
Containment imminent
Oil onshore
Assess adequacy of surface collecting agents (604)
Effective
Ineffective
Implement (Appendix D)
Go to oil onshore
Evaluate conventional clean-up techniques (502)
Adequate
Inadequate
Implement manual*
Evaluate natural cleaning potential (503)
Acceptable
Unacceptable
Allow to clean naturally
Select Dispersant (504) Evaluate Impacts (505)
Acceptable
Unacceptable
Consider use of dispersants (Appendix C)
Consider extraordinary actions

*Manual of Practice for Protection and Cleanup of Shorelines: Volumes 1 and 2 (EPA-600/7-79-187a and 187b)

Figure 501-1. Sequence for consideration of dispersant use on shorelines.

502 CONVENTIONAL PROTECTION AND CLEANUP POTENTIAL

Mechanical Cleanup of Shorelines

Physical removal is generally the preferred method for cleaning oil contaminated shorelines. The EPA Manual of Practice for Protection and Cleanup of Shorelines (EPA-600/7-79-187a and 187b) describes cleanup techniques and sets guidelines for the selection of the proper technique for various spill and shoreline conditions.

Dispersant use on shorelines may be acceptable if one or more of the following conditions exist:

1. Insufficient physical cleanup equipment and/or manpower to effectively clean the shoreline in a timely manner.

2. No land or water access for mechanical cleanup equipment.

3. Contaminated beach sediment cannot be removed and replaced without causing unacceptable environmental damage.

Insufficient Resources. This condition may occur in the event of a large oil spill where many kilometers of shoreline are contaminated and there is insufficient cleanup equipment available locally or regionally. The same condition may also arise for a smaller spill in a remote area where required equipment is not available.

Lack of Access. Certain shoreline areas may be inaccessable to cleanup equipment from land because there are no roads in the region, or there are marshlands or cliffs behind the beaches. Access from the water may not be possible because of heavy surf conditions or shoals.

Sediment Removal. Removal of contaminated sediment from a shoreline may cause unacceptable environmental damage. This may occur if (1) sediment removal upsets a delicate habitat, (2) natural replacement of the removed sediment by littoral processes would not be sufficient, (3) sediment removal would cause excessive erosion of backshore areas, or (4) a local supply of similar sediment was not available to replace the sediment during the cleanup operation.

503 NATURAL CLEANING POTENTIAL

The acceptability of allowing an oiled shoreline to clean naturally is based on the rate and degree of natural cleaning and their compatibility with desired recovery and resumption of use of the area.

Several factors influence the natural cleaning potential of a shoreline area. These factors in the order of their importance are:

1. The energy level of the shoreline area.
2. The type and volume of the spilled oil and its depth of penetration.
3. The prevailing climate.

Energy Levels

The energy level of a shoreline can be defined as the mechanical energy imparted to the shoreline by waves and wind and is generally indicated by the size and frequency of waves which impact the shoreline. Shorelines which have predominately onshore winds will have higher energy levels than shorelines where the wind blows predominately offshore. Fetch is an indication of the degree of exposure or shelter for a given shoreline and is defined as the length of water surface area over which winds can generate waves. Other indications of shoreline energy levels for sediment beaches are the height of a beach berm or ridge and sediment sorting on a given shoreline. The height of the berm (on sand beaches) or ridge (on pebble/cobble beaches) is a direct function of wave height; increases in wave height and wave energy create higher berms or ridges.

The degree of sorting of beach sediments can be a useful indicator of shoreline energy levels. High wave-energy beaches are usually characterized by well-sorted sediments (i.e., only one size of sediments). In sheltered, low-energy locations the beach is usually composed of a mixture of sediment sizes. The higher the energy, the higher the probability of high natural cleaning rates.

Figure 503-1 indicates the relationship between the factors discussed above. It can be used to approximate the energy level of various coastline areas.

Oil

The type and volume of oil and its depth of penetration will influence the natural cleaning potential of a shoreline. Viscous sticky oils (Class C) will tend to stick to impervious surfaces like rocks and sea walls, but will not penetrate sediment beaches in depth. Lighter, less viscous oils (Class A) will only thinly coat impervious surfaces but can deeply penetrate sediment beaches. Penetration and burial insulate the oil from surface radiation and wave energy. Oil will generally penetrate larger grain sediments and will be buried most readily in areas characterized by high sedimentation rates (e.g., longshore sand transport, freshwater sediment loading). Thick viscous oil coatings on impervious surfaces resist wave scouring to a greater extent than thin, less viscous coatings.

FETCH	PREVAILING WINDS	COASTAL EXPOSURE	BERM/RIDGE HEIGHT	SEDIMENT SORTING	ENERGY LEVEL
Long (>200km)	Onshore	Straight (Open)	High	Good	High
↑	↑	↑	↑	↑	↑
Short (<50km)	Offshore	Indented (Sheltered)	Low	Poor	Low

Figure 503-1. Shoreline energy levels.

Climate

Prevailing air and water temperatures can effect the persistence of oil on a shoreline. The colder the air and water temperatures, the more likely the oil will persist. Rates of physical and biological (microbial) degradation decrease as temperatures decrease. Conversely, as temperatures rise, oil becomes more mechanically and biologically susceptible to removal.

Assessment

Accurate estimates of the natural cleaning potential of a shoreline can be difficult without taking long term field measurements. However, Figures 503-2 (sediment beaches) and 503-3 (non-sediment beaches) can be used to indicate whether a specific shoreline has a high or low potential for natural cleaning. A high potential would mean that most of the oil should be removed naturally from a shoreline in several days to months. A low potential for natural cleaning means that a majority of the oil would remain on the shoreline for months to years and that some oil may remain for decades.

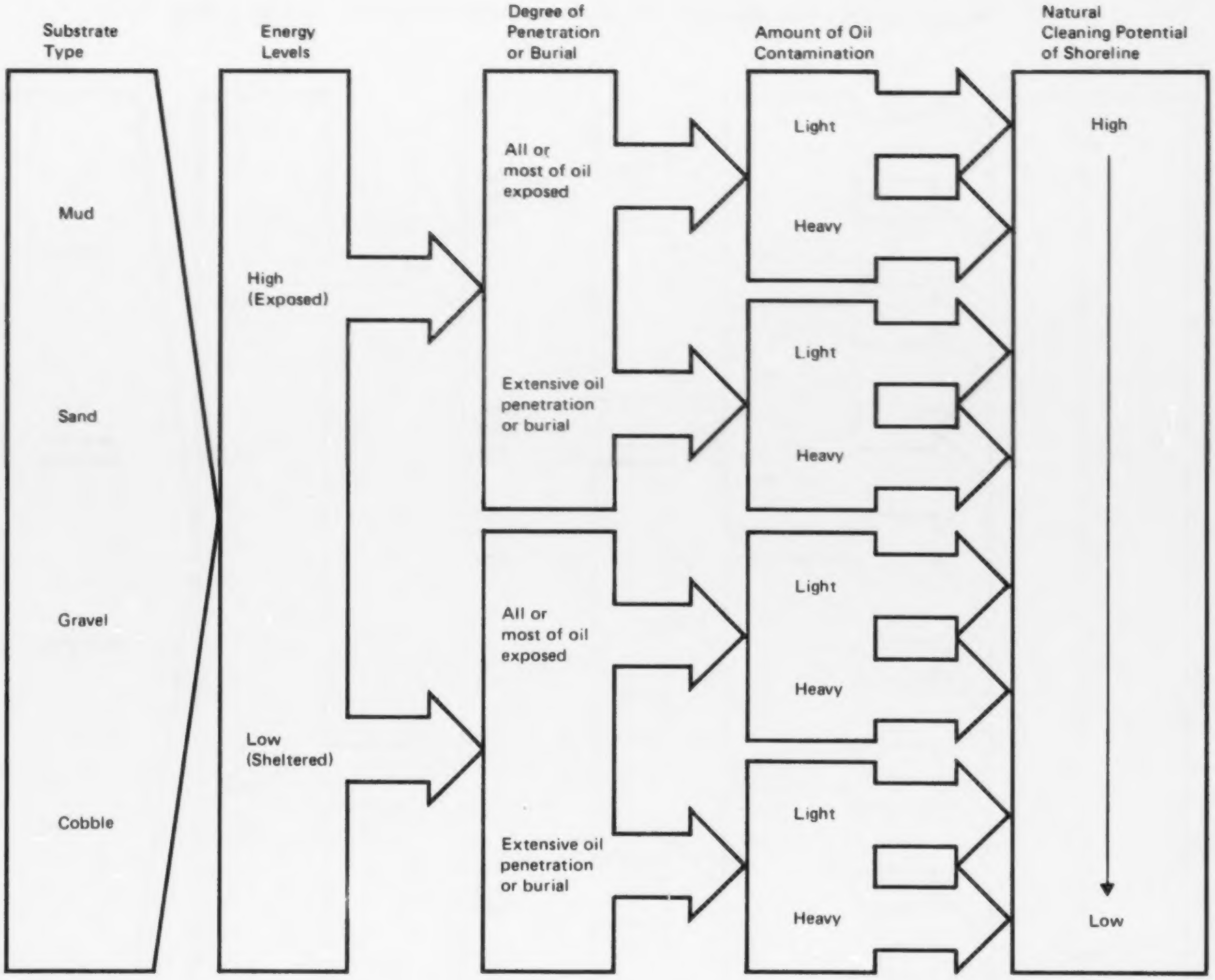

Substrate Type
Energy Levels
Degree of Penetration or Burial
Amount of Oil Contamination
Natural Cleaning Potential of Shoreline
Mud
Sand
Gravel
Cobble
High (Exposed)
Low (Sheltered)
All or most of oil exposed
Extensive oil penetration or burial
All or most of oil exposed
Extensive oil penetration or burial
Light
Heavy
Light
Heavy
Light
Heavy
Light
Heavy
High
Low

Figure 503-2. Natural cleaning potential for sediment shoreline.

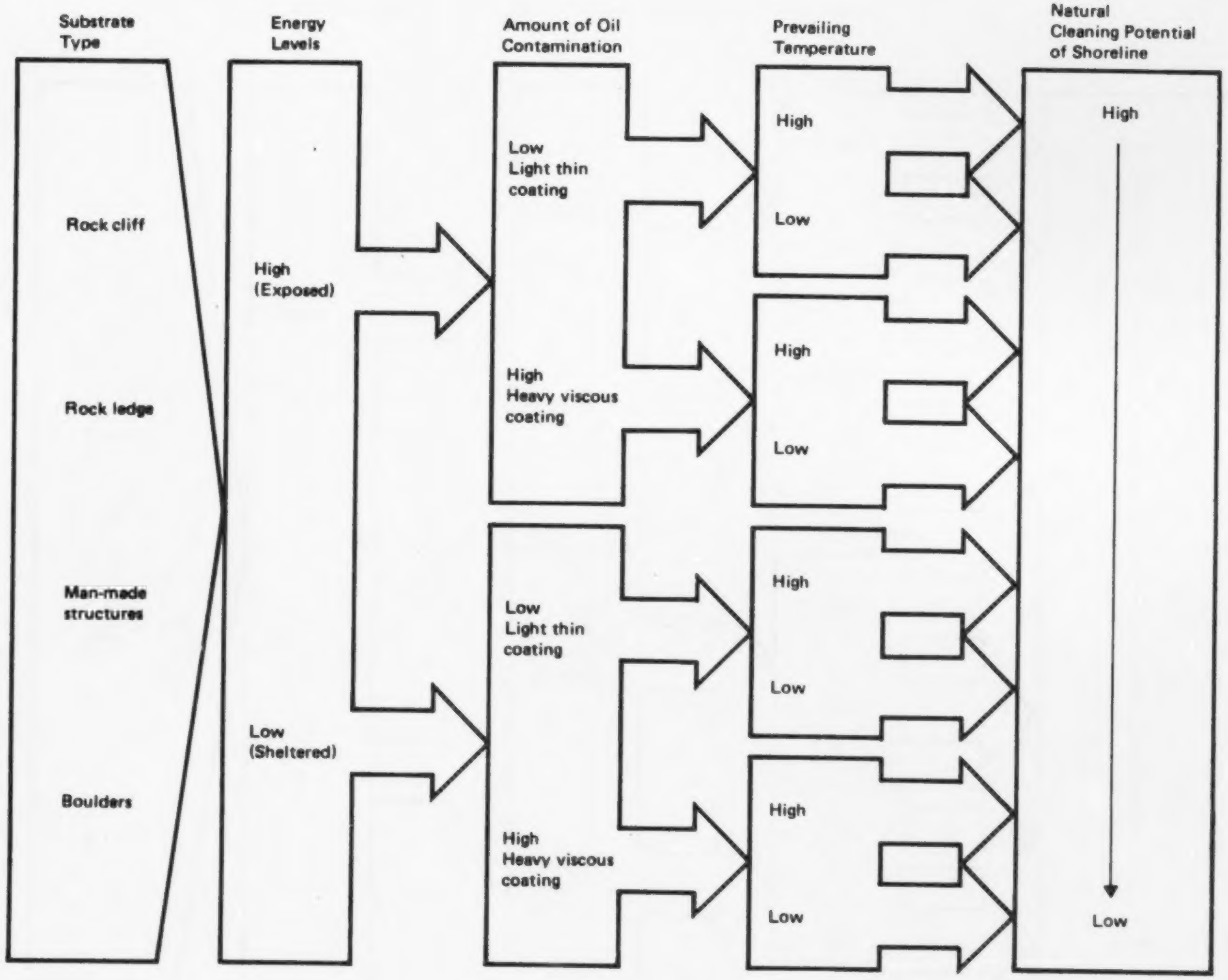


Figure 503-3. Natural cleaning potential for non-sediment type shorelines.

504 SELECTION OF APPLICATION TECHNIQUES, DISPERSANT, AND DOSAGE

Once dispersant cleaning has been deemed acceptable, the proper dispersant, application technique, and dosage must be selected for the specific area to be cleaned. Selection is based on the nature of the surface to be cleaned and the mode of cleaning, rather than the oil type, which will be weathered and viscous in most cases.

In general, dispersants are best suited for use on impervious surfaces such as rock cliffs or platforms, seawalls, docks, etc., but can also be used on sand or cobble beaches. Manufacturers' recommendations for dispersants should be reviewed prior to application.

Selection of Dispersant Type

There are two types of dispersants which can be used to clean oil-contaminated shorelines. These are:

- hydrocarbon base dispersants
- water base dispersants

Table 504-1 indicates the type of substrate on which the two types of dispersants can be used. Table 504-2 relates the dispersant type to application equipment and methods.

Hydrocarbon Base Dispersants. The use of hydrocarbon base dispersants to clean shorelines is generally limited to impervious surfaces contaminated with highly viscous or weathered oil. Application to sand, gravel, or cobble beaches may result in deeper oil penetration of the sediments. Typically, these dispersants are applied neat and allowed to stand for a short period of time before agitation by water jets or wave action. Successful use depends on uniform application, adequate contact time, and agitation of the oil/dispersant mixture. The contact time allows the agent to penetrate and loosen the oil, and the agitation by wave action or water jets ensures thorough removal and dilution.

Highly viscous or weathered soils may require several applications for effective removal. Stiff brooms can be used on solid surfaces to work the dispersant into the oil, thereby increasing effectiveness. Steam may be beneficial in final removal.

Water Base Dispersants. Water base dispersants are usually applied in diluted form (1-10 percent in water) through a high-pressure spray system or fire hose. Their primary objective is to prevent the oil reforming or adhering to other surfaces as the force of the water spray striking the contaminated surface provides the mechanism for oil removal. If used undiluted on unconsolidated surfaces, they may drive the oil deeper into the substrate. Therefore, application to sand, gravel, or cobble beaches should be uniform and conducted just prior to the rising tide. Application to seawalls, rock cliffs, docks, and other impervious surfaces is generally more effective using very high pressure hydroblasting equipment but can also be accomplished at lower pressures using fire hoses. For highly viscous or weathered oils,

TABLE 504-1. DISPERSANT TYPE VERSUS SUBSTRATE TYPE

	DISPERSANT TYPE	
SUBSTRATE TYPE	Hydrocarbon Base	Water Base
Mudflats		X
Sand/Gravel		X
Cobble		X
Boulder	X	X
Rock Platform	X	X
Rock Cliffs	X	X
Man-made Structures	X	X

TABLE 504-2. EQUIPMENT AND APPLICATION METHODS FOR DIFFERENT DISPERSANT TYPES

DISPERSANT TYPE	APPLICATION METHOD	EQUIPMENT USED	DILUTION METHOD
Hydrocarbon base	Applied neat at low pressure and volume	Hand-held or back-pack sprayers, low pressure/volume pumps, single or multi-nozzle spray lances, or agricultural spraying equipment (fire pumps, hoses, and nozzles for flushing)	Not Applicable
Water base	Applied in solution at concentrations of 1-10%; usually at high pressure and volume.	Hand-held or back-pack sprayers, high pressure/volume pumps, injection pumps, fire nozzles or spray lances, or agricultural spraying equipment.	Premixed, or diluted through eduction or injection.

a presoak using hydrocarbon base or concentrate dispersant applied full strength may be necessary.

The dispersant/water solution can be prepared by premixing, eduction, or injection into a high pressure water stream. The high pressure nature of the application system not only delivers the dispersant to the oil but also mixes it in and removes the dispersed oil from the substrate. Sand, gravel, or cobble beaches may require repeated applications after every few tidal cycles. This permits wave action to turn over cobbles or the top layers of sediment exposing previously untreated oil.

Selection of Dispersant Cleanup Techniques

Several different methods can be used to implement dispersant cleaning of a shoreline. Table 504-3 lists two techniques and several application methods for using dispersants on a shoreline. The following factors influence the selection of a dispersant shoreline cleaning technique:

- type of substrate
- shoreline energy level
- sensitivity of the shoreline to oil and dispersant
- type and amount of oil contamination
- vehicle access and trafficability on a shoreline

Two decision guides have been prepared to help the user evaluate these factors for a given shoreline and select the preferred dispersant cleanup technique. Figure 504-1 discusses sediment-type shorelines, and Figure 504-2 discusses non-sediment-type shorelines.

Implementing Dispersant Shoreline Cleaning

The intertidal zone should be treated just ahead of the rising tide so that wave action can agitate the dispersant/oil mixture and disperse it into the sea yet still allow adequate contact time for maximum effectiveness. Contaminated substrate lying above the high water line should be treated with dispersant and pushed into the surf zone or flushed thoroughly with seawater.

Field experience involving the use of dispersants in conjunction with flushing equipment indicates that dispersants do not necessarily improve cleaning rates but do disperse the removed oil, preventing it from coagulating and penetrating sediments.

Dispersant Dosage

Specific dosage rates for dispersant cleaning of shorelines have not been developed. Manufacturers' recommendations should be followed initially and adjusted based on the effectiveness of the cleaning operation.

TABLE 504-3. DISPERSANT BEACH CLEANING TECHNIQUES

1. Dispersant applied directly to oil on beach; tidal and wave action remove dispersed oil.

    A. Vehicle. Application of water base dispersant by spray bar from tank truck or beach vehicle.

    B. Manual. Application of water base dispersant by fire hose or hydrocarbon base dispersant by spray system.

2. Dispersant applied to oil on shoreline (beach, rocks, sea walls, etc.) and oily runoff collected.

    A. Application of water base dispersant by fire hose or hydrocarbon base dispersant by portable spray systems to oiled area, collect runoff.

    B. Push loose substrate into stock pile on back shore area, apply water base dispersant to stock pile and collect runoff.

    C. Injection of water base dispersant into high pressure washing system--collect runoff.

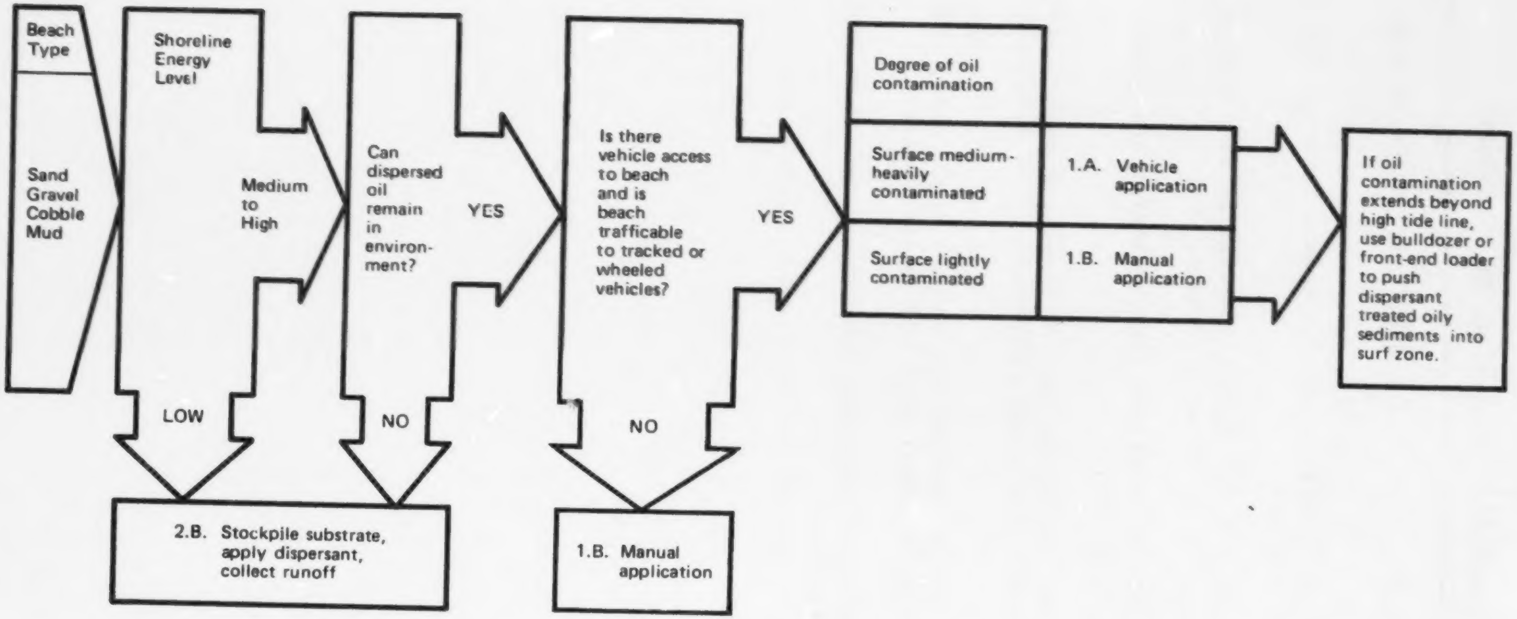

Beach Type
Sand
Gravel
Cobble
Mud
Shoreline Energy Level
Medium to High
LOW
2.B. Stockpile substrate, apply dispersant, collect runoff
Can dispersed oil remain in environ-ment?
YES
NO
Is there vehicle access to beach and is beach trafficable to tracked or wheeled vehicles?
YES
NO
1.B. Manual application
Degree of oil contamination
Surface medium-heavily contaminated
1.A. Vehicle application
Surface lightly contaminated
1.B. Manual application
If oil contamination extends beyond high tide line, use bulldozer or front-end loader to push dispersant treated oily sediments into surf zone.

Figure 504-1. Decision guide - dispersant beach cleaning techniques for sediment beaches (1.A. etc., refers to techniques listed on Table 504-3).

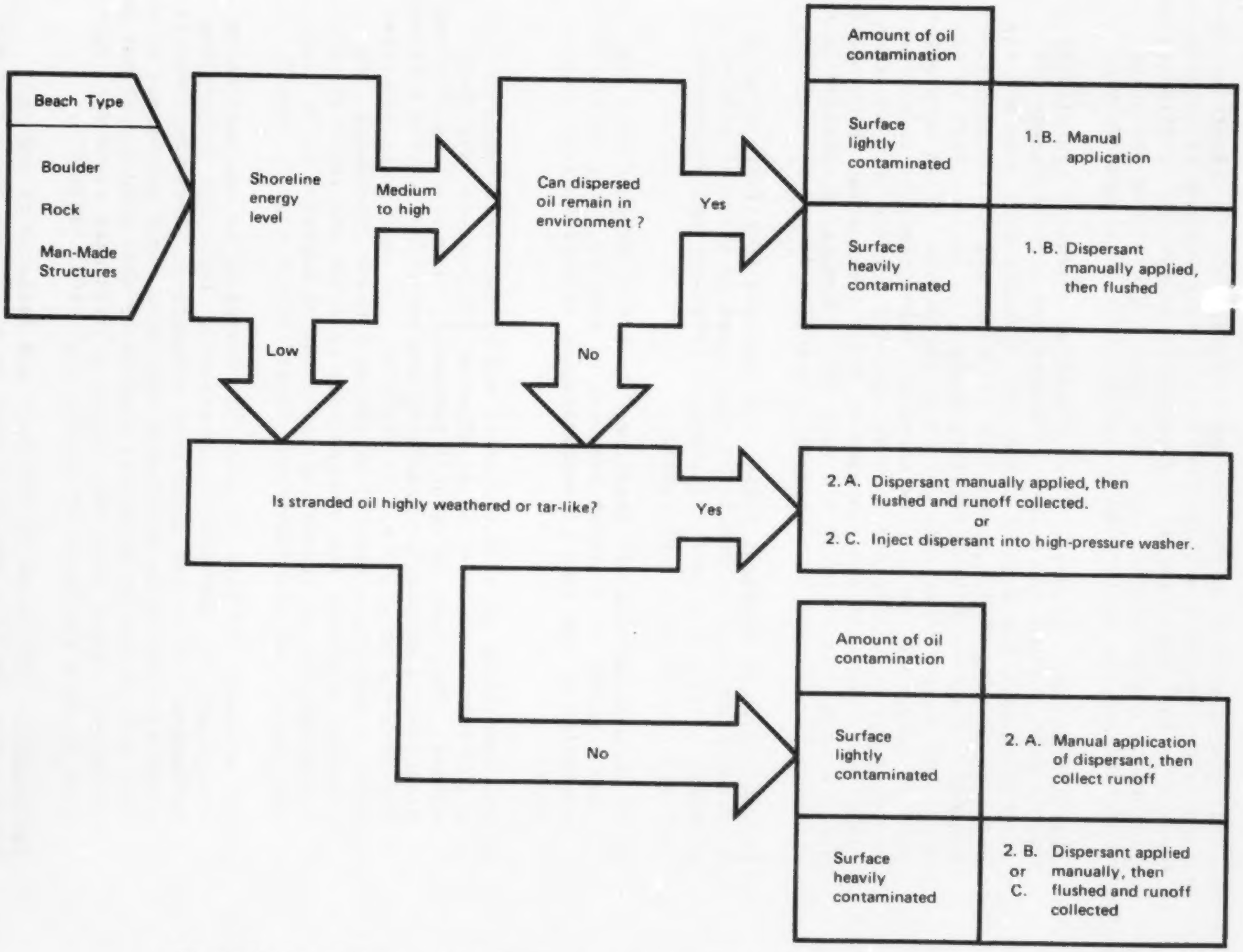

Beach Type
Boulder
Rock
Man-Made Structures
Shoreline energy level
Medium to high
Low
Can dispersed oil remain in environment ?
Yes
No
Amount of oil contamination
Surface lightly contaminated
1. B. Manual application
Surface heavily contaminated
1. B. Dispersant manually applied, then flushed
Is stranded oil highly weathered or tar-like?
Yes
2. A. Dispersant manually applied, then flushed and runoff collected.
or
2. C. Inject dispersant into high-pressure washer.
No
Amount of oil contamination
Surface lightly contaminated
2. A. Manual application of dispersant, then collect runoff
Surface heavily contaminated
2. B. or C. Dispersant applied manually, then flushed and runoff collected

Figure 504-2. Decision guide - dispersant beach cleaning techniques for non-sediment beaches (1.B. etc., refers to techniques listed on Table 504-3).

505 ECOLOGIC CRITERIA

The final consideration in determining acceptability of dispersant use on shorelines is the relative ecologic effect. Dispersant use is acceptable when it results in the least overall environmental damage and facilitates the speediest return to normal conditions. The following criteria can guide decisions which regard the environmental consequences of dispersant use:

1. Existing Damage. If most or all shoreline organisms are already coated with oil and the nearshore waters are carrying heavy oil concentrations, the bulk of damage has probably been done and the additive effects of dispersant and dispersed oil will probably be minimal. When evaluating existing damage, it is important to consider the three-dimensional nature of the beach. Often contamination is restricted to surface coatings; sub-surface or under-rock habitats may be unaffected. While removing surface contamination, dispersant treatment may contaminate these lower areas which previously escaped the incoming floating oil. Chemical dispersion in the vicinity of emergent or submergent vegetation is not recommended.

2. Contamination of Adjacent Areas. In addition to effects on-site, dispersant application should be considered in terms of effects on adjacent areas. The case for chemical treatment may be considered from two related points of view:

   a) In some situations oil leaching from a contaminated site may pose a threat to a nearby resource or amenity. Any uncontrolled expansion of the zone of contamination is ecologically undesirable.

   b) Oil removed by natural processes and by chemical treatment will ultimately be distributed on adjacent beaches and near-shore waters. When left to natural processes, removal is usually comparatively slow and the resulting concentrations in the surrounding environment are low. In addition, the weathering processes tend to facilitate removal of the more toxic components. In chemical treatment the removal rate is rapid and local short-term concentrations of removed material can be expected to be higher. The toxicity of the dispersant itself should also be considered.

   The movement and fate of materials dispersed in the near-shore environment are not clearly understood. Until the controlling mechanisms can be evaluated more accurately, shoreline chemical dispersion should be considered only when rapid mixing and dilution with receiving waters is assured or when oily runoff can be collected. Areas with high mixing and flushing rates are typified by open configuration and/or high tidal variation.

3. Persistence. All forms of treatment are designed to reduce persistence, and none should be used in situations where they may result in an increase. Generally, if dispersion results in oil penetrating shoreline or nearshore sediments, its persistence will

be increased. Persistence should be considered both in terms of the initial site of contamination and the ultimate fate of the removed oil.

Oil has been observed to adhere to suspended sediments and sink. The effect of dispersant treatment on this phenomena is uncertain. In areas of high turbidity, sediment sinking of dispersed oil should be considered possible.

Note: Actual persistence of buried oil should consider the role of littoral processes. If a shoreline is undergoing seasonal or storm-related offshore sediment movement, any buried oil may be quickly removed.

4. Recovery. Recolonization of a shoreline largely depends on the suitability of that shoreline for settlement and survival of recruits. Oil left exposed on the shoreline surface or gradually released there will inhibit the recovery process. Spores and larvae that recolonize a polluted shoreline will largely originate from adjacent unpolluted shores and not from the survivors of that shoreline. The proximity of such "seed" areas improves the opportunities for accelerated recovery.

   In general, dispersant use should not expand environmental damage if extensive mortality has already occurred. However, dispersant use may be desirable if treatment will decrease the persistence of the oil on the shoreline and encourage the biological recovery process.

SECTION 600

CRITERIA FOR USE OF SURFACE COLLECTING AGENTS

601 GENERAL

Surface collecting agents (SCA) are defined by the EPA as surface film forming chemicals for controlling oil layer thickness. By regulating the thickness, the film formed by the agent temporarily keeps the oil from spreading excessively. The application of SCA is discussed in Appendix D.

The primary use is to concentrate the oil, thus making physical recovery more effective. It may also be used to temporarily protect a shoreline by fending off the oil slick from a particular area.

SCA use requires the verbal permission of the Federal OCS which may be granted either in person or by telephone. The OSC may authorize use of an SCA if:

(1) it will result in the least overall environmental damage or interference with designated water use.

(2) provide a key element in the most effective system for removing oil or hazardous substance discharge from the water environment.

The OSC must also ascertain that the prevailing environmental, meteorological, and oceanographic conditions at the spill site are compatible with the agent's use.

602 ENVIRONMENTAL CRITERIA CONTROLLING USE

Limitations on SCA Use

Collecting agent surface tension forces are comparatively weak and approximately equivalent to those generated by a 3 mph wind or a surface current of 0.1 knot. Therefore, an SCA cannot keep oil from moving against most winds and currents. The agent can, however, control oil slick spread in moderate currents and in winds up to 20-25 mph, thereby facilitating cleanup and reducing the area of contamination if a slick comes ashore.

SCA effectiveness will lessen with time. A properly applied film can usually maintain its integrity for a period of several hours although this is highly dependent on meteorological activity and the surface conditions of the water. Choppy wave action and wind can break the continuous chemical film formed by the agent, allowing the oil to resume spreading through the breaks. Additional applications can prolong the effective containment period.

The effectiveness of SCA is reduced in waters which are heavily contaminated with soaps or detergents. In addition, they are ineffective on oils in a solidified or semisolidified state such as weathered viscous oils, oils with high paraffin content, or water-in-oil emulsions. Table 602-1 provides a summary of conditions under which the agents are effective and not effective.

When To Use Surface Collecting Agents

The decision to use a surface collecting agent to control an oil slick depends on several factors.

Table 602-2 presents a series of questions which can guide determination of the feasibility of SCA use for a given spill situation. If the answers to the questions of the checklist are affirmative, then the spill is a good candidate for the use of an SCA for oil containment or shoreline protection.

Ecologic Considerations

While SCA have a measurable level of toxicity, they are typically applied in very low dosages and over limited areas (i.e., along the perimeter or leading edge of a slick). They also operate at the surface and evaporate relatively rapidly. (SCA contain carrier solvents that may be partially soluble). Open water application in accordance with manufacturers' recommendations should not result in concentrations causing quantifiable effects.

Greater ecologic concern should be given to shoreline application, where direct agent-amenity contact and higher concentrations are possible, especially with continual or repeated applications. Surface collecting agents hold promise for the temporary protection of wetlands and mangroves if applied properly. Since their impacts on vegetation are not well-known, use should probably be limited to application where significant contamination is indicated.

A final consideration should be directed to the possible misapplication of an SCA. If applied seaward of the oil and shoreline, the oil may be forced ashore greatly compounding cleanup and damage. Wind and tidal shifts

TABLE 602-1. CONDITIONS UNDER WHICH SURFACE COLLECTING AGENTS ARE EFFECTIVE AND ARE NOT EFFECTIVE

Condition	Effective	Not Effective In
Waves	swells up to 4 to 6 ft in height	breaking waves, white caps, or surf
Currents	currents up to 0.1 kt. May be useful in deflecting oil from shorelines at higher currents, or in controlling the growth of a slick moving in a higher current	against currents greater than 0.1 kt
Wind	winds up to 20-25 mph	against winds of greater than 3 mph
Temperature	air temperature above pour point of collecting agent	air temperatures below pour point collecting agent
Oil type	fluid petroleum oils	weathered viscous oils, high parafin oils and water-in-oil emulsions
Debris or vegetation	areas with little or no floating debris or oiled vegetation	areas with floating debris or where oil has contaminated aquatic vegetation
Time	short periods of time (up to 6 hr)	

TABLE 602-2. CHECKLIST FOR DETERMINING FEASIBILITY OF USING SURFACE COLLECTING AGENTS FOR OIL CONTAINMENT AND SHORELINE PROTECTION

DETERMINING FACTOR	YES	NO
1. Are waves nonbreaking and less than 4 to 6 feet in height?	—	—
2. Is surface current less than 0.1 knots?	—	—
3. Is wind less than 20-25 mph (containment) or less than 3 mph towards shoreline (protection)?	—	—
4. Is air temperature greater than pour point of agent?	—	—
5. Is spilled oil in a fluid state?	—	—
6. Is there an absence of floating debris or aquatic vegetation in spill area?	—	—
7. Are there areas of special biological significance (i.e., bird nesting areas, shellfish beds, marshlands, etc.) or commercial significance (high-amenity beaches, etc.)?	—	—
8. Is an oil skimmer available to collect contained oil?	—	—
9. Is there equipment available to supply the surface collecting agent?	—	—

can result in the generation of similar problems. Inshore use requires a clear understanding of its performance and the nature of area to be treated.

Application Rates

Current maximum application rates have been set by EPA at 2 gallons per linear mile or 1 ounce per 20 feet with allowances for reapplication every six hours but not to exceed three times in any 24-hour period. An increase in these maximum rates is currently being reviewed by EPA. Current approved application rates can be obtained through the OSC.

603 APPLICATION

SCA can be effective in controlling spilled oil when used in conjunction with booms and skimmers. If applied in a timely manner to the slick perimeter the agent can reduce the amount of oil boom required for slick containment and concentrate oil in a smaller area for more effective skimming. However, belt and disc skimmers may lose effectiveness when used in the presence of SCA. If a disc or belt becomes wetted by a collecting agent, it may tend to repel oil instead of recovering it. Therefore, when these skimmers are used on an oil slick surrounded by a collecting agent, they should be deployed in the middle of the slick and not driven into the slick through the chemical barrier. Similar precautions should be taken when using sorbents with an SCA. The sorbents should be placed directly on the oil slick inside of the chemical barrier and not dragged through the barrier.

In quiet harbor or marina areas SCA can be applied to the water between the oil and the shoreline, structures, boats, etc. to repel oil until recovery can be implemented. They can be used in inaccessible locations between ships and under docks by applying the chemical to the water behind the oil, causing it to move out to areas where recovery techniques can be applied.

General Application Method

Application of SCA should be conducted as follows:

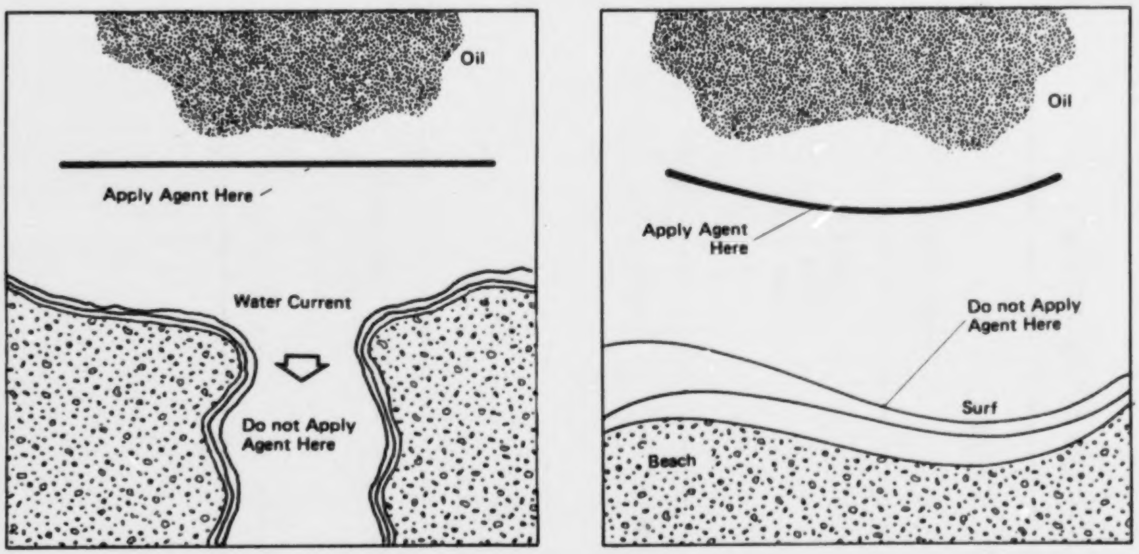
- Apply the agents as quickly as possible. Agents are most effective when applied during the early stages of a spill when the oil is in the initial phases of spreading.
- Apply the agents full strength and not diluted.
- Apply the agents as a stream or coarse spray in a narrow path close to the edge of the oil slick.
- Do not apply the agent to the slick itself. Agents sprayed onto an oil slick will be ineffective.

Figure 603-1 illustrates methods of applying a collecting agent under several different conditions.

Selection of SCA Application Techniques

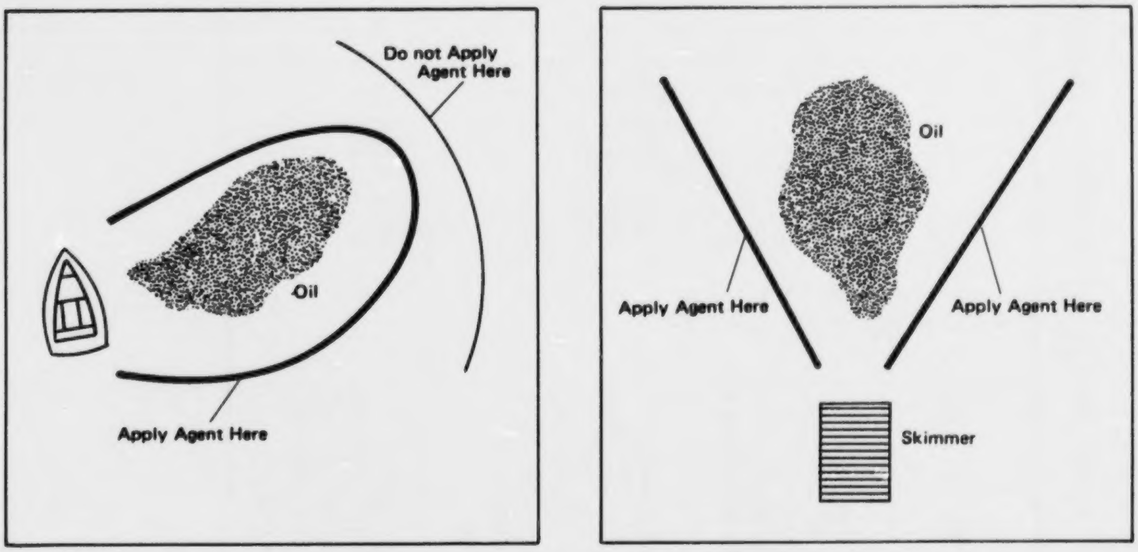
There are several different agent application techniques for controlling an oil spill. The most common methods incorporate the use of spray units mounted on airplanes, helicopters, boats, or carried by hand. In the absence of spray equipment, the agents can be applied using drip pots or squirt bottles. For small spills occurring in semi-confined areas such as docks, harbors, estuaries, etc., the collecting agents should be applied with backpack sprayers or hand-held spray lances.

Moderate to large spills occurring in the nearshore area or out to sea are best treated with vessel or helicopter mounted spray equipment. Very large offshore spills may require application by light, fixed-wing aircraft. Table 603-1 summarizes application techniques in relation to different spill situations.



Shoreline Protection

Shoreline Protection



Slick Concentration

Windrow Concentration

Figure 603-1. Collecting agent application.

TABLE 603-1. APPLICATION TECHNIQUES FOR SURFACE COLLECTING AGENTS

Surface Collecting Agent Use	Application Technique		
	Small Spill	Moderate Spill	Large Spill
Concentrate oil--agent is applied to edges of oil slick to concentrate oil for subsequent boom containment or pickup by a skimmer	1. Back pack or hand-held sprayer	1. Helicopter spray system	1. Fixed wing aircraft
Move oil from underneath structures--collecting agent is applied behind an oil slick underneath a dock or wharf to drive oil out from underneath structure to facilitate cleanup	1. Back pack or hand-held sprayer	1. Hand-held lance with chemical pump	n/a
Shoreline protection--collecting agent is applied in water ahead of an oil slick and on front of the shoreline area to be protected	1. Back pack or hand-held sprayer 2. Drip pots	1. Boat spray system 2. Helicopter	1. Fixed wing wing aircraft 2. Helicopter

APPENDIX A

ANNEX X - SCHEDULE OF CHEMICAL AND OTHER ADDITIVES* TO REMOVE OIL AND HAZARDOUS SUBSTANCES DISCHARGES

2001 General

2001.1 This Schedule has been prepared by the U.S. Environmental Protection Agency pursuant to section 1(2) of Executive Order 11735. This Schedule applies to the waters of the United States and adjoining shorelines, the waters of the Contiguous Zone, and the high seas beyond the Contiguous Zone in connection with activities under the Outer Continental Shelf Lands Act or the Deep Water Port Act of 1974, or which may affect natural resources belonging to, appertaining to, or under the exclusive management authority of the United States (including resources under the Fishery Conservation and Management Act of 1976).

2001.2 This Schedule applies to the use of any chemicals or other additives as hereinafter defined that may be used to remove oil and remove or neutralize hazardous substances discharges. Any chemical agent or other substance not specifically defined in this schedule will be considered by EPA on a case-by-case basis for use in the removal of oil and hazardous substances discharges.

2001.3 This Schedule favors development and utilization of sorbents, skimmers, booms and other mechanical control methods to remove or mitigate oil and remove, mitigate, or neutralize hazardous substances discharges from the environment with subsequent proper disposal.

2001.4 It is the intent of this Schedule that the use of chemicals and additives to remove or mitigate the effects of oil or hazardous substances discharges shall cause the least overall environmental impact.

2001.5 In implementing this Schedule and in maintaining its relationship with other Federal and State agencies, EPA shall recognize that some States may have more stringent laws, regulations or written policies regulating the use of chemicals in the removal of oil and hazardous substance discharges, in which case such laws, regulations or policies shall govern.

2001.6 It has been determined that because of the overriding need for prompt initiation of discharge removal actions no formal permit, as provided for by Sec. 402 of the Act, shall be required before application of chemicals to mitigate the effects of a discharge. The provisions of Sec. 1510.21(f) and 1510.36(a)(3) of this Plan shall apply.

2002 Definitions

Materials applied to oil or floating hazardous substances discharges are defined as follows:

2002.1 Chemical agents are those elements, compounds, or mixtures that disperse, dissolve, emulsify, neutralize, precipitate, reduce, solubilize, oxidize, concentrate, congeal, entrap, fix, gell, make the pollutant mass more rigid or viscous, or otherwise facilitate the mitigation of deleterious effects or removal of the pollutant from the water.

2002.2 Dispersing Agents are those chemical agents which emulsify, disperse, or solubilize oil into the water column or act to further the surface spreading of oil slicks in order to facilitate dispersal of the oil into the water column.

2002.3 Surface Collecting Agents are those chemical agents which are a surface film forming chemical for controlling oil layer thickness.

2002.4 Biological Additives are microbiological cultures, enzymes, or nutrient additives that are deliberately introduced into an oil or hazardous substance spill for the specific purpose of encouraging biodegradation to mitigate the effects of a spill.

2002.5 Burning Agents are those materials which, through physical or chemical means, improve the combustibility of the materials to which they are applied.

2002.6 Sinking Agents are those materials which are applied to oil and hazardous substance spills to sink floating pollutants below the water surface.

2002.7 Mechanical removal methods include the use of pumps, skimmers, booms, earthmoving equipment, and other mechanical devices.

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*Council on Environmental Quality. National Oil and Hazardous Substances Pollution Contingency Plan: Final Revision. 40 CFR Part 1510 (Federal Register. Vol. 45, No. 55, March 19, 1980).

2002.6 Sorbents are essentially inert and insoluble materials which are used to remove oil and hazardous substances from water through a variety of sorption mechanisms. Examples include: straw, expanded perlite, polyurethane foams, reclaimed paper fibers, peat moss.

2003 Dispersing Agent Program for Spills of Oil and Applicable Hazardous Substances

2003.1 Authorization for Use of Dispersing Agents

2003.1–1 Major and medium discharges. Dispersing agents may be used in any place, at any time, and in quantities designated by the OSC when their use will:

2003.1–1.1 In the judgment of the OSC, prevent or substantially reduce hazard to human life.

2003.1–1.2 In the judgment of the EPA RRT member on a case-by-case basis, in consultation with appropriate State or Federal agencies, prevent or reduce substantial hazard to a major segment of the population(s) of vulnerable species of waterfowl; or,

2003.1–1.3 In the judgment of the EPA RRT member on a case-by-case basis, in consultation with appropriate State and Federal agencies, result in the least overall environmental damage, or interference with designated water uses.

2003.1–2 Minor discharge. The provisions of section 2003.1–1 shall apply.

2003.2 Special Restrictions on Dispersing Agent Use:

2003.3.2–1 Chemical agents shall not be considered for use as dispersing agents unless technical product data have been provided and accepted in accordance with 2003.3 except when the judgment of the OSC the hazards discussed in 2003.1–1.1 are so imminent that the time delay for obtaining a dispersant agent that is in compliance with 2003.3 would be excessive.

2003.2–2 Federal officials responsible for oil and hazardous substance spill response activities at all levels shall develop effective programs to insure that dispersants that are available for use in appropriate spill response actions are dispersants with adequate technical data on file with EPA. This effort will help preclude the avoidance of the EPA technical data program by manufacturers or suppliers who might wish to take advantage of the emergency conditions provision of 2003.2–1.

2003.2–3 For all situations where dispersants are used, accurate records shall be kept on dispersant types, brands, application rates and methods, effectiveness, environmental impacts, plus any other pertinent observations.

2003.3 Technical Product Data For Dispersing Agents

2003.3–1 Technical product data as outlined in 2003.3–4 on the physical, chemical and toxicity characteristics of a dispersing agent shall be submitted to the Oil and Special Materials Control Division (WH–548), Environmental Protection Agency, Washington, D.C. 20460, at least 60 days prior to the use of the agent. Within 60 days of receipt of the data, EPA will inform, in writing, the submitter on the adequacy of the data provided. If additional information is requested or EPA desires to perform tests, the dispersing agent may not be considered for use until the additional needs have been satisfied and the submitter so notified.

2003.3–2 Information furnished in accordance with 2003.3–4 shall be maintained on file by the Environmental Protection Agency, Oil and Special Materials Control Division, (WH–548) Washington, D.C. 20460, to provide technical guidance to OSCs on the acceptable circumstances of use and dosage rates for dispersing agents. Any changes in the composition or formulation of the dispersing agent that will affect any of the data being requested in 2003.3–4 shall be immediately brought to the attention of EPA and testing of the agent will be repeated prior to the use of the revised dispersing agent.

2003.3–3 The acceptance and maintenance of product data by EPA does not constitute approval of the dispersing agent nor does it imply compliance with any EPA criterial or minimum standards for such agents. The OSC will determine which dispersing agent may be used for a spill event on a case-by-case basis using all available information in making such a decision. To avoid possible misinterpretation and misrepresentation of the EPA's role in this technical product data program, the manufacturer's representatives may use only the EPA letter advising compliance with 2003.3–4 in any advertisements or technical literature on the dispersing agent. The EPA letter must be used in its entirety. Failure to comply with these restrictions or any other improper reference to EPA in attempting to demonstrate EPA approval of the dispersing agent for use on spills of oil or hazardous substances shall constitute grounds for removing the technical product data from EPA files, which would preclude use of the dispersing agent except as noted in 2003.2–3 for imminent hazards.

2003.3–4 Required Technical Product Data

2003.3–4.1 Name, brand, or trademark, if any, under which the chemical agent is sold.

2003.3–4.2 Name, address and telephone number of the manufacturer, importer or vendor.

2003.3–4.3 Name, address and telephone number of primary distributers or sales outlets.

2003.3–4.4 Special handling and worker precautions for storage and field application. Maximum and minimum storage temperatures to include optimum ranges as well as temperatures that will cause phase separations, chemical changes or otherwise damage effectiveness of the chemical agent.

2003.3–4.5 Shelf Life.

2003.3–4.6 Recommended application procedure(s), concentration(s) and conditions for use depending upon water salinity, water temperature and types and ages of the pollutants.

2003.3–4.7 Dispersant Toxicity—Use standard toxicity test methods described in EPA Report "Standard Dispersant Effectiveness and Toxicity Test" (EPA R2–73–201, May 1973) pages 22–34. This report may be obtained from the Oil and Special Materials Control Division (WH–548), EPA, Washington, D.C. 20460.

2003.3–4.8 Dispersant Effectiveness—Use standard effectiveness test methods in EPA R2–73–201, May 1973, pages 11–21.

2003.3–4.9 Flash Point—Select appropriate method from the following: ASTM—D 56–70; ASTM—D 92–72; ASTM—D 93–72; ASTM—D 1310–67.

2003.3–4.10 Pour Point—Use ASTM D 97–66

2003.3–4.11 Viscosity—Use ASTM D 445–72

2003.3–4.12 Specific Gravity—Use ASTM D 1298–67

2003.3–4.13 pH—Use ASTM D 1293–65

2003.3–4.14 Ionic Activity—Use Weatherburn Test as described below:

Ionic activity tests (Weatherburn Test)

Reagents: 1. Dye solution: 0.03 grams methylene blue, 12 grams concentrated sulfuric acid, 50 grams anhydrous sodium sulfate dissolved in water to make a total of one liter solution.

2. Anionic surfactant solution—0.5% Aerosol OT (Sodium dioctyl sulfo succinate).

3. Chloroform.

Procedure: 1. Into a 25 ml. test tube, place 8 ml. of dye solution and 5 ml. chloroform. Add anionic surfactants solution drop by drop, shaking vigorously between drops and allowing phases to separate. Continue adding dropwise until the two layers are equal in color and intensity viewed in reflected light. Usually 10 to 12 drops of anionic solution are required.

2. Now add 2 ml. of 0.1% solution of the unknown and shake vigorously.

Results: 1. Chloroform phase (lower) is deeper in color and aqueous phase is mostly colorless—anionic is positive.

2. Water phase (upper) is deeper in color than the chloroform phase—cationic is positive.

3. Both phases are more or less the same color—probably a nonionic.

4. If the aqueous phase has become milky and hence slightly lighter in color, it may still be nonionic. Soaps do not react in this procedure. If both anionics and nonionics are present, the reaction of this test will be anionic positive.

2003.3–4.15 Miscibility—Use the test described below which is a modification of military specification MIL–C–22230 (ships):

One part of the dispersing agent is mixed with 100 parts of synthetic sea water. The solution is agitated for one hour and any visible separation of the dispersing agent should be noted after this period of agitation. The test is to be performed with water temperatures at both 20°C and 0°C. The synthetic sea water shall be formulated as follows:

Sodium Chloride (grams)	150.0
Magnesium Chloride, hexahydrate (grams)	66.0
Calcium Chloride dihydrate (grams)	9.6
Sodium Sulfate anhydrous (grams)	24.0
Distilled water to make a total of (liters)	6.0

2003.3–4.16 Dispersing Agent Components

Itemize by chemical name and percentage by weight of each component of the total formulation. The percentages will include maximum, minimum and average weights in order to reflect quality control variation in manufacture or formulations. At least the following major components shall be identified in complying with 2003.3–4.16.

(a) Surface active agents.
(b) Solvents.
(c) Additives.

If requested by the submitter, information from 2003.3–4.16 will be handled as trade secrets under provisions of P.L. 90–23, the Administrative Procedures Act.

2003.3–4.17 Heavy Metal and Chlorinated Hydrocarbons

Using reliable analytical chemistry techniques, state the concentrations or upper limits of the following materials:

Arsenic, cadmium, chromium, copper, lead, mercury, nickel, zinc, plus any other metals that may be reasonably expected to be in the sample. Atomic absorption methods should be used and the detailed analytical methods and sample preparation shall be fully described;

Cyanide using standard colorimetric procedures;

Chlorinated hydrocarbons. Gas chromatography should be used and the detailed analytical methods and sample preparation shall be fully described.

2003.3–5 Analytical Laboratory Requirements for Technical Product Data:

2003.3–5.1 The required tests shall be performed by a qualified laboratory.

2003.3–5.2 The technical product data submission shall include the identity of the laboratory, the qualifications of the laboratory staff including professional biographical information for individuals responsible for any tests, and laboratory experience with similar tests. Laboratories performing bioassay tests for dispersant or surface collecting agent toxicity must demonstrate previous bioassay experience in order for their results to be accepted. EPA will not approve the selection of laboratories by intended submitters of technical product data prior to submission of the data. It is the responsibility of the submitter to select competent analytical laboratories based on the guidelines contained herein.

2003.3–5.3 EPA reserves the right to refuse to accept a submission of technical product data because of lack of qualifications of analytical laboratory, significant variance between submitted data and any laboratory confirmation performed by EPA, or other circumstances that will result in inadequate or inaccurate environmental information on the dispersing agent.

2004 Surface Collecting Agent Program for Spills of Oil and Applicable Hazardous Substances

2004.1 Authorization for Use of Surface Collecting Agents: Major, Medium and Minor Discharges.

2004.1-1 The OSC may authorize use of surface collecting agents on a case-by-case basis when their use will:

2004.1-1.1 Result in the least overall environmental damage or interference with designated water uses, and

2004.1-1.2 Provide a key element in the most effective system for removing oil or hazardous substances discharge from the water environment.

2004.1-2 Mechanism for authorizing use. The OSC may authorize the use of a surface collecting agent verbally when on scene or by telephone prior to arriving on scene. In all cases, the OSC is obligated to comply with the provisions of 2004.2 prior to making such authorization. A review of the capabilities and expertise of the owner or operator or cleanup contractor prior to the occurence of the spill incident would be most beneficial in situations where telephone authorization is desired or contemplated.

2004.2 Restrictions on Surface Collecting Agent Use.

2004.2-1 The OSC may authorize the use of surface collecting agents only after being informed of the environmental conditions at the point of intended use. These environmental conditions include air and water temperatures, wind conditions, wave and current conditions, presence and relative density of debris and other floating matter on the water, type and condition of the oil or hazardous substance spilled, special biological factors such as waterfowl sanctuaries, wildlife refuges, spawning or nursery grounds, shellfish beds, swamp areas, etc., and the availability of removal equipment that could be employed to remove the collected material from the water. Information on environmental conditions should be evaluated by the OSC from the standpoint that conditions such as strong winds, choppy waters, low temperatures, debris, and aquatic vegetation can adversely affect the performance of collecting agents or complicate further removal operations. The performance can also vary with types of oils or hazardous substances. The agents can be effective with thin films of light oils but have little value with thick layers of heavy, viscous oils. The agents should not be used unless adequate removal equipment is available to remove the collected oil.

2004.2-2 A chemical agent shall not be used as a surface collecting agent unless the provisions of 2004.3 are complied with and EPA has informed the manufacturer's representative that the product is acceptable for use as a surface collecting agent.

2004.3 Technical Product Data for Surface Collecting Agents.

2004.3-1 Technical product data as specified in 2004.3-4 shall be provided to the Oil and Special Materials Control Division (WH-548), EPA, Washington, D.C. 20460, at least 60 days prior to the use of the agent. The use of existing surface collecting agents may be authorized by the OSC without complying with 2004.3 for 120 days from the effective date of this Annex. Within 60 days of receipt of the data, EPA will inform, in writing, the submitter on the adequacy of the data submitted. If additional data are requested or EPA desires to perform additional tests, the surface collecting agent may not be used until these additional needs have been satisfied and the submitter so notified.

2004.3-2 Information furnished in accordance with 2004.3-4 shall be maintained on file by the EPA, Oil and Special Materials Control Division (WH-548), Washington, D.C. 20460, to provide technical guidance to OSCs on the acceptable circumstances of use, dosage rates and special problems in the use of surface collecting agent. Any changes in the composition or formulation of the surface collecting agent that will affect any of the data requested in 2004.3 shall be immediately brought to the attention of EPA and testing of the agent will be repeated prior to the use of the revised formulation of the surface collecting agent.

2004.3-3 EPA will review technical product data for surface collecting agents and will issue approvals for agents meeting certain criteria. At present, the only minimum criterion established is for solubility which is described in 2004.13. This criterion classifies the substance as a surface collecting agent but is not an indication of the effectiveness or toxicity of the material. Other product data such as toxicity, chemical components, and physical characteristics will be reviewed and, if the combined effects of these data and other factors will result in excessive hazard to the aquatic life, work safety, or other elements of the environment in the judgment of EPA, the Agency may refuse to approve the use of the agent.

EPA may, from time to time, establish minimum criteria for the data being requested and may also require additional data to assist in arriving at a judgment on the environmental acceptability of collecting agent usage.

To avoid possible misinterpretation and misrepresentation of the EPA's role in the surface collecting agent technical product data program, the manufacturer's representatives may use only the EPA letter advising compliance with 2004.3-4 in any advertisements or technical literature on the collecting agent. The EPA letter must be used in its entirety. Failure to comply with these restrictions or any other improper reference to EPA in attempting to demonstrate EPA approval of the surface collecting agent beyond that stated in the letter for use on spills of oil or hazardous substances shall constitute grounds for removing the technical product data from EPA files which would preclude use of the surface collecting agent.

2004.3-4 Required Technical Product Data

2004.3-4.1 Name, brand, or trademark, if any, under which the surface collecting agent is sold.

2004.3–4.2 Name, address and telephone number of the manufacturer, importer or vendor.

2004.3–4.3 Name, address and telephone number of primary distributors or sales outlets.

2004.3–4.4 Special handling and worker precautions for storage and field application. Maximum and minimum storage temperature to include optimum ranges as well as temperatures that will cause phase separation, chemcial changes, or otherwise damage effectiveness of the surface collecting agent.

2004.3–4.5 Shelf Life.

2004.3–4.6 Recommended application procedure(s), concentration(s) and conditions for us depending upon water salinity, water temperature and types and ages of the pollutants.

2004.3–4.7 Surface Collecting Agent Toxicity—Use standard toxicity test methods described in EPA Report "Standard Dispersant Effectiveness and Toxicity Test" (EPA R2–73–201, May 1973) pages 22–34. This report may be obtained from the Oil and Special Materials Control Division (WH–548), EPA, Washington, D.C. 20460.

2004.3–4.8 Flash Point—Select appropriate method from the following: ASTM—D 56–70; ASTM—D 92–72; ASTM—D 93–72; ASTM—D 1310–67.

2004.3–4.9 Pour Point—Use ASTM D 97–66

2004.3–4.10 Viscosity—Use ASTM D 445–72

2004.3–4.11 Specific Gravity—Use ASTM D 1298—67

2004.3–4.12 pH—Use ASTM D 1293–65

2004.3–4.13 Interim Test to Distinguish Between Surface Collecting Agents and Other Spill Cleanup Chemicals.

In order to distinguish between surface collecting agents and other chemical materials, this interim test procedure was developed. This test procedure is not an efficiency test. It is to be used only to distinguish between surface collecting agents and dispersants.

Scope

1. Procedure to be used to determine the solubility in water under standard conditions of oil spill control chemicals.

Method Summary

2. Five (5) milliliters of the chemical under test are intimately mixed with ninety-five (95) milliliters of distilled water, allowed to stand undisturbed for one hour, and then the volume of the upper phase is determined to the nearest 1 milliliter.

Apparatus

3. (a) Mixing cylinder, 100 milliliter subdivisions and fitted with glass stoppers.

(b) Pipettes: Volumetric pipette, 5.0 millileter.

(c) Timers

Procedure

4. Add 95 milliliters of distilled water 22°C+/−3°C to a 100 milliliter mixing cylinder. To the surface of the water in the mixing cylinder, add 5.0 milliliters of the chemical under test. Insert the stopper and invert the cylinder 5 times in 10 seconds. Set upright for one (1) hour at 22°C+/−3°C and then measure the chemical layer at the surface of the water. The major portions of the chemical added (75%) should be at the water surface as a separate and easily distinguished layer.

2004.3–4.14 Surface Collecting Agent Components

Itemize by chemical name and percentage by weight each component of the total formulation. The percentages will include maximum, minimum and average weights in order to reflect quality control variations in manufacture or formulations. At least the following major components shall be identified.

(a) Surface active agents

(b) Solvents

(c) Additives

If requested by the submitter, information for 2004.3–4.14 will be handled as trade secrets under provisions of Pub. L. 90–23, the Administrative Procedures Act.

2004.3–4.15 Heavy Metals and Chlorinated Hydrocarbons

Using reliable analytical chemistry techniques, state the concentrations or upper limits of the following materials:

Arsenic, cadmium, chromium, copper, lead, mercury, nickel, zinc, plus any other metals that may be in the sample. Atomic absorption methods should be used and the detailed analytical methods and sample preparation shall be fully described;

Cyanide using standard colorimetric procedures;

Chlorinated hydrocarbons. Gas chromatography should be used and the detailed analytical methods and sample preparations shall be fully described.

2004.3–5 Analytical Laboratory Requirements for Technical Product Data:

Follow stipulations in 2003.3–5

2005 Biological Additive Program for Spills of Oil and Applicable Hazardous Substances

2005.1 Authorization for use of biological additives.

2005.1–1 All discharges, the OSC may authorize the use of biological additives on water or shorelines only after obtaining the approval of the EPA representative to RRT. The manufacturer or supplier of microbiological cultures or enzymes must obtain approval from State and local public health and pollution control officials and furnish evidence of such approval to the EPA RRT representative.

2005.2 Special Restrictions on Biological Additive Use

2005.2–1 Microbiological cultures and enzyme mixtures shall not be considered for use as biological additives unless technical product data have been provided and accepted in accordance with 2005.3.

2005.2–2 The OSC must be supplied with the chemical composition and ratios of primary nutrients or nutrient additives prior to seeking approval for their use.

2005.3 Technical Product Data for Biological Additives

2005.3–1 Technical product data as outlined in 2005.3–4 on the constituents of a biological additive shall be submitted to the Oil and Special Materials Control Division (WH–548), Environmental Protection Agency, Washington, D.C. 20460, at least 60 days prior to the use of the additive. Within 60 days of receipt of the data, EPA will inform in writing the submitter on the adequacy of the data provided.

If additional information is requested or EPA desires to perform tests, the biological additive may not be used until the additional needs have been satisfied and the submitter so notified.

2005.3–2 Information furnished in accordance with 2003.3–4 shall be maintained on file by EPA to provide technical guidance to OSCs on the acceptable circumstances of use and application rates for biological additives. Any changes in the composition of the biological additive that will affect any of the data being requested in 2005.3–4 shall be immediately brought to the attention of EPA, and testing of the additive will be repeated prior to the use of the revised biological additive.

2005.3–3 The acceptance and maintenance of product data by EPA does not constitute approval of the biological additive nor does it imply compliance with any EPA criteria or minimum standards for such additives. The OSC will determine which biological additive may be used for a spill event on a case-by-case basis using all available information in making such a decision. To avoid possible misinterpretation and misrepresentation of EPA's role in this technical product data program, the manufacturer's representatives may use only the EPA letter advising compliance with 2005.3–4 in any advertisements or technical literature on the biological additive. The EPA letter must be used in its entirety. Failure to comply with these restrictions or any other improper reference to EPA in attempting to demonstrate EPA approval of the biological additive for use on spills of oil or hazardous substances shall constitute grounds for removing the technical product data from EPA files which would preclude use of the biological additive.

2005.3–4 Required Technical Product Data

2005.3–4.1 Name, brand, or trademark, if any, under which the biological additive is sold.

2005.3–4.2 Name, address and telephone number of the manufacturer, importer or vendor.

2005.3–4.3 Name, address and telephone number of primary distributors or sales outlets.

2005.3–4.4 Special handling and worker precautions for storage and field application. Maximum and minimum storage temperatures.

2005.3–4.5 Shelf Life.

2005.3–4.6 Recommended application procedure(s), concentration(s) and conditions for use depending upon water salinity, water temperature and types and ages of the pollutants.

2005.3–4.7 Statements on the expected effectiveness of the additive including degradation rates and the test conditions and data on effectiveness.

2005.3–4.8 For microbiological cultures furnish the following information:

Listing of all microorganisms to species,[1]

Percentage of each species in the composition of the additive,[1]

Optimum pH and temperature range for use of the additive,

Special nutrient requirements, if any,

Separate listing of the following and test methods for such determinations: Salmonella, fecal coliform, Shigella, Staphylococcus Coagulase positive, and Beta Hemolytic Streptococci.

2005.3–4.9 For enzyme additives furnish the following information:

Enyzyme name(s),

International Union of Biochemistry (I.U.B.) number(s),

Source of the enzyme,

Units,

Specific Activity,

Optimum pH and temperature range for the use of the additive.

2005.3–5 Laboratory Requirements for Technical Product Data: Follow stipulations in 2003.3–5.

2006 Burning Agent Program for Spills of Oil and Applicable Hazardous Substances

2006.1 Authorization for Use of Burning Agents

2006.1–1 All discharges. The OSC may authorize the use of burning agents only when they will:

2006.1–1.1 Prevent or substantially reduce imminent threats to human life, limb, or property;

2006.1–1.2 Result in the least environmental harm when compared to other removal or disposal methods.

2006.1–2 Prior to authorizing use under 2006.1–1.2, the OSC must obtain approval of the EPA RRT representative and all applicable State and local public health pollution control officials.

2006.2 Special Restrictions on Burning Agent Use

2006.2–1 The OSC will evaluate the suitability of burning agents on a case-by-case basis. Burning agents should be inert materials that will not, in themselves, be a water pollutant. The addition of oils (such as gasoline or solvents) as an igniter shall be avoided unless it is necessary under 2006.1–1.

2006.2–2 A technical data program for burning agents will not be established at this time.

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[1] If requested by the submitter, these items will be handled as trade secrets under the provisions of the Administrative Procedures Act (Pub. L. 90–23).

2007 Sinking Agent Program for Spills of Oil and Applicable Hazardous Substances

2007.1 Authorization for Use of Sinking Agents

2007.1-1 All Discharges

Sinking agents shall not be applied to discharges of oil or hazardous substances on the navigable water of the United States or the contiguous zone.

2008 Mechanical Methods and Sorbents Program for Spills of Oil and Hazardous Substances

2008.1 Authorization for Use of Mechanical Methods and Sorbents

2008.1-1 All Discharges

2008.1-1.1 As stated in 2001.3, it is the policy of this Schedule to favor the use of mechanical methods and sorbents for removal of oil and hazardous substances spills. The OSC has the authority to use or prohibit specific mechanical methods and sorbents on a case-by-case basis. The OSC will select methods and materials that, in his judgment, will be most effective in expeditiously removing the spilled material and mitigating the related damages, and will minimize secondary pollution from the removal or mitigation operation. Prior to authorizing the use of sorbents, the OSC shall take into consideration hydrographic and meteorological conditions as well as the characteristics of the sorbent and the availability of adequate containment and removal equipment.

2008.1-1.2 A technical data program for mechanical methods and sorbents will not be established at this time.

[FR Doc. 80-8214 Filed 3-18-80; 8:45 am]

APPENDIX B

TECHNIQUES FOR DISPERSION AT SEA

GENERAL

This appendix provides a general description of the major types of application systems suitable for oil spill treatment at sea. The information presented is not meant for use in equipment construction but rather to describe operation principles and methods for calibration and dosage control. Detailed information regarding design specifications can be found in the American Petroleum Institute's Dispersant Application Manual or directly from equipment manufacturers.

Vessel and aircraft application systems are discussed in this section. Hand spray equipment has been used for some applications at sea, but is considered limited in capacity and application rate. Hand spray systems are described in Appendix D.

VESSEL APPLICATION SYSTEMS

Vessel application systems may be divided into three general categories: low-pressure spray booms, high-pressure spray booms, and single-jet or fire systems. The basic types and specifications of vessel systems are listed in Table B-1.

Vessels suitable for dispersant application must be seaworthy under the spill conditions, relatively fast, and capable of carrying a reasonable amount of chemical, either as deck cargo or integral tankage. Ocean-going tugs, work boats, and some larger fishing vessels generally meet these requirements. Smaller craft can be used for close-to-shore application and when surface conditions permit.

Low Pressure Spray Boom-Systems

Low pressure systems (such as the Warren Spring Laboratory [WSL]-type) are intended for installation on vessels of opportunity, and consist of pumping systems which deliver dispersant solutions through spray nozzles that are attached to outrigger booms. The nozzles produce flat sprays and are spaced to overlap slightly at the water surface. Designed to deliver undiluted dispersant, these systems operate at low pressures and volumes (<20 psi and <20 gal/min respectively).

Several variations of the WSL-type system have been developed, including one for offshore use and a light-duty unit for inshore use. Both are designed to apply hydrocarbon base dispersants (full-strength) or water base

TABLE B-1. BASIC VESSEL APPLICATION SYSTEMS

System Type	Representative System	Dispersant Type	Application	Pump Parameters	Method of Dosage Control	External Mixing
Spray Boom Low-Pressure	WSL-offshore	Hydrocarbon Base	Full strength	91 l/min (20 gpm)	Vessel speed; dosage can be doubled by shutting off one boom	Yes
		Concentrate, Water-base	10:1	Seawater: 20 gpm Injector: 2 gpm	Vessel speed; dosage can be doubled by shutting off one boom	Yes
	WSL-inshore	Hydrocarbon-base Concentrate, Water-base	Full strength	32 l/min (7 gpm)	Vessel speed; dosage can be doubled by shutting off one boom	Yes
Spray Boom High-Pressure	Injection type (Halliburton)	Concentrate and Water-base	Variable dilution	Seawater: 90-100 psi; 300 gpm dispersant injector: variable to 25 psi; 25 gpm	Vessel speed; eductor setting	May be required
	Eduction type (Exxon)	Concentrates and Water-base	Variable dilution	80-100 psi; 100-150 gpm	Vessel speed; eductor setting	May be required
Single Jet Spray	Onboard fire systems	Concentrates and Water-base	Variable dilution	Variable	Vessel speed; eductor rate; spray angle	May be required
	Portable pump system	Concentrates and Water-base	Variable dilution	Variable	Vessel speed; eductor rate; rate angle	May be required

or concentrate dispersants using adaptor kits. The primary components of the offshore system for full strength application are shown in the schematic diagram in Figure B-1. The basic system uses a pump which draws undiluted dispersant directly from a tank or drums, and supplies it to the booms. To apply water-diluted dispersants, the main pump draws water from the sea while a second pump injects the dispersant into the seawater stream at a fixed rate as shown in Figure B-2. (Due to the low flow rate, eductors cannot be used on this sytem). The booms are mounted to each side of the vessel and supported by two masts and a series of guy wires. To facilitate mixing, breaker boards can be towed behind the spray booms to provide mixing energy.

The smaller WSL-type inshore system is essentially a scaled down version of the offshore system. It is designed for use on small boats having a fully loaded freeboard of 2 to 2-1/2 feet. The system consists of a single spray boom extending out both sides of the vessel, pump, breaker boards (optional), and rigging. The dispersants are applied through two nozzles at a total rate of 5 to 7 gal/min and pressure of 12 psi. As with the offshore system, water diluted dispersants can be applied by modification with an adapter kit.

High Pressure Spray Boom Systems

This system is similar in appearance to the low pressure offshore system; however, the dispersants are applied in an aqueous solution at pressures of 90 to 100 psi and volumes ranging from 80 to 300 gpm. The increase in application pressure permits use of eductors to introduce the dispersant and provides greater initial mixing energy. In addition, the spray booms are typically mounted forward, ahead of the bow wake to insure dispersant-oil contact without bow wave disturbance. This position also takes advantage of the mixing energy supplied by the bow wave.

The primary components of these systems include spray booms, a seawater pump, an eductor or metering pump, a dispersant supply, a mast or other means of boom support, rigging, and hoses. If a metering pump is used, it must be coupled to the seawater pump motor or have its own power source. Eductors require no additional source of power. A schematic of a system using eductors is given in Figure B-3. Systems using metering pumps are similiar to that shown in Figure B-2.

High Pressure Jet Spray Systems

The single jet spray system is used only with water-base or concentrate dispersants. The system is similar to the spray boom system except that single nozzles are used instead of booms with multiple nozzles, and a slightly larger capacity pump may be required. A schematic of a typical single jet spray system is given in Figure B-4.

Adjustable fire nozzles which can produce sprays from a course stream to a fine wide cone are generally used. They can be hand-held or attached to monitors which are operated manually or automatically. A nozzle can be located at either side of the vessel, preferably ahead of the bow wave, to increase coverage.

Fire fighting systems are found on many vessels of opportunity and may be used in place of the portable components of the high pressure jet spray

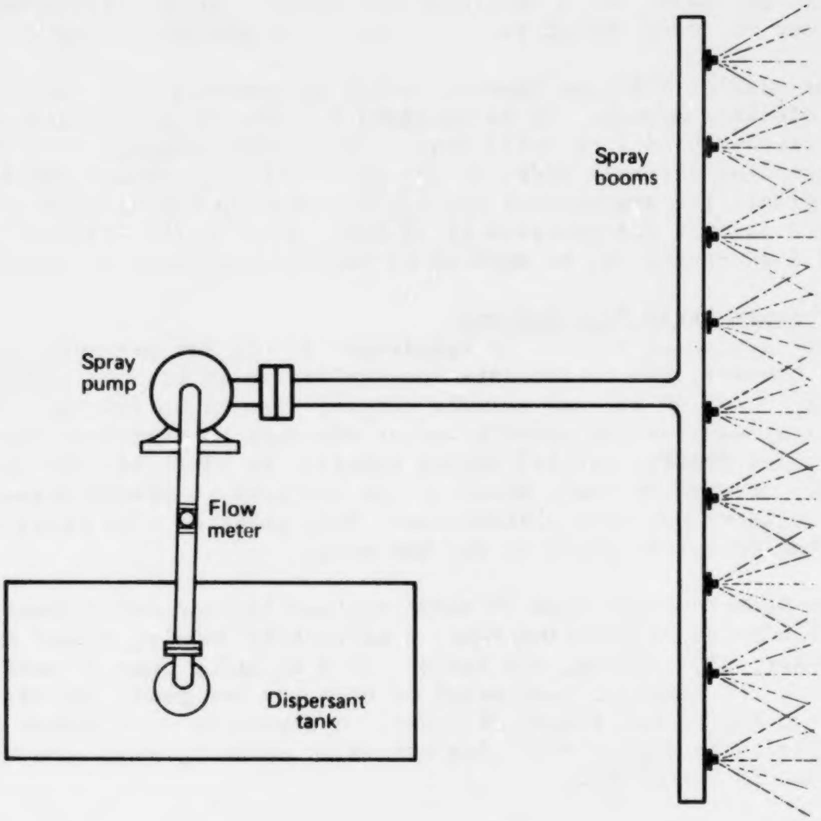


Figure B-1. Schematic of low pressure vessel spraying system — full-strength application.

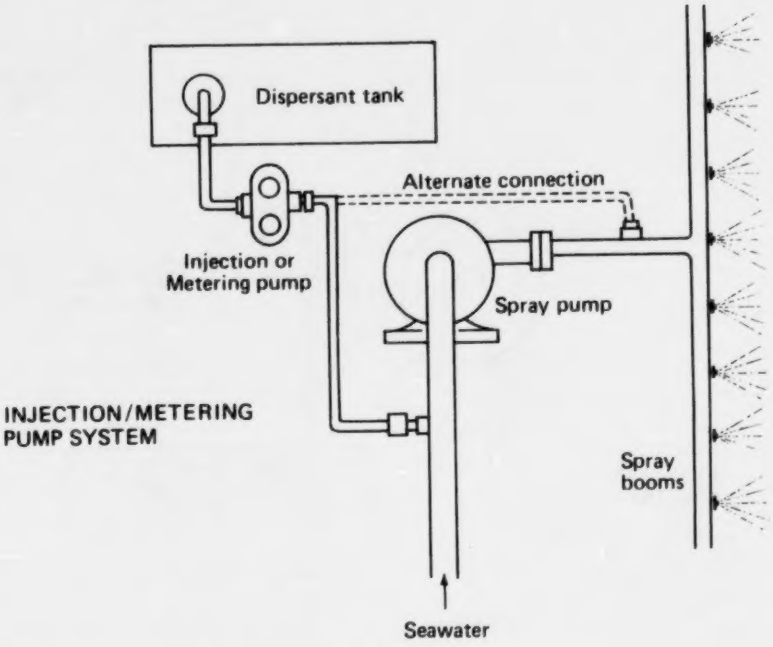


Figure B-2. Schematic for vessel spraying system — diluted applications.

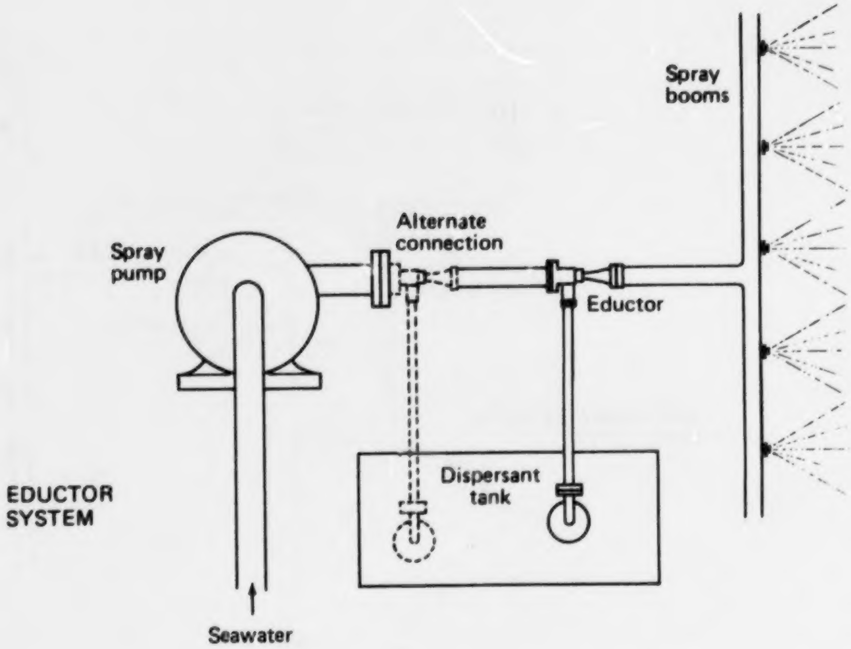


Figure B-3. Schematic for high pressure vessel spraying system using eductors to introduce dispersant.

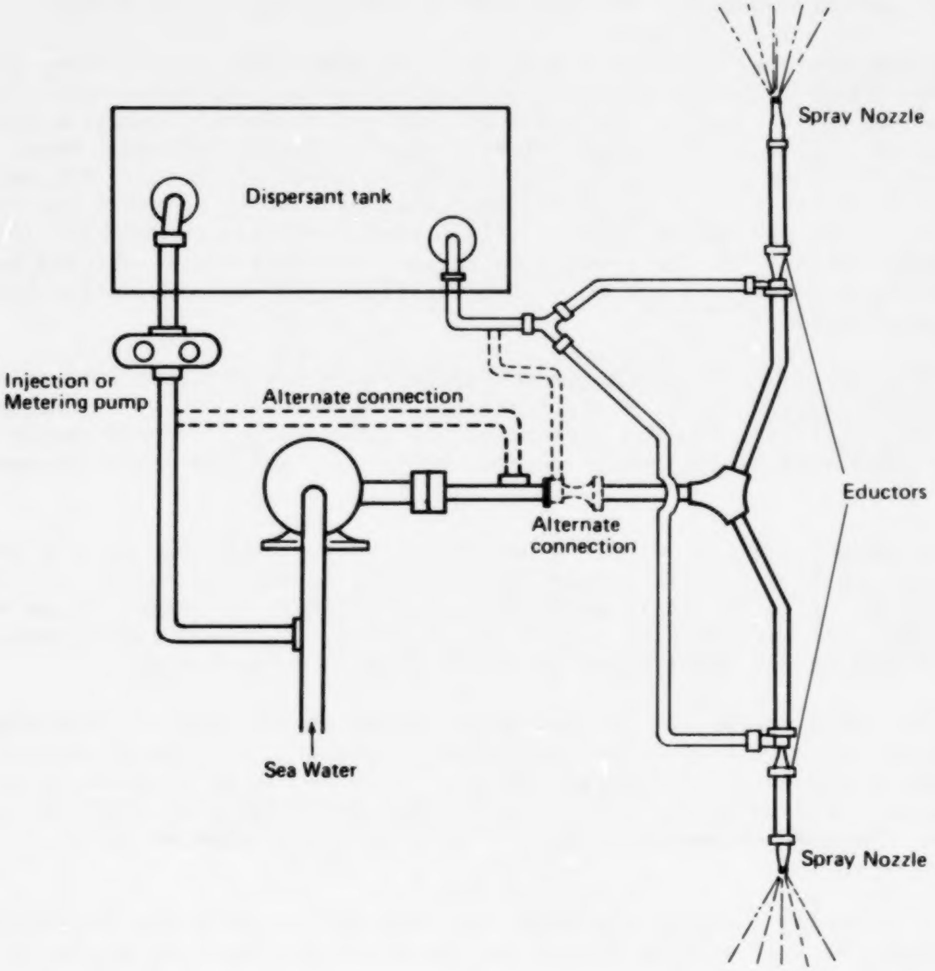


Figure B-4. Schematic – high pressure jet spray system.

system. Simple installation of an eductor in the main line to the nozzle(s) usually provides all the necessary modification. Figure B-5 shows installation as used on a small U.S. Coast Guard fire fighting system.

Calibration

To accurately regulate dosage rates, the system must first be calibrated so the actual output or application rate of dispersant is known. Once calibrated, actual dosage can be regulated by controlling vessel speed.

Spray Boom Systems. The first step is to determine the total output of the system. (Pump output ratings may not reflect actual system output.) The pump is started and all valves and equipment are set in normal operating position. The output volume is determined by holding a graduated container under one of the spray nozzles for one minute or another convenient period. The amount of liquid collected is multiplied by the number of nozzles to yield the system output gallons per minute (gpm). This procedure should be repeated for a few different nozzles and the results averaged. Pressure can be checked by installing a pressure gauge on or between the discharge port of the pump and the spray boom.

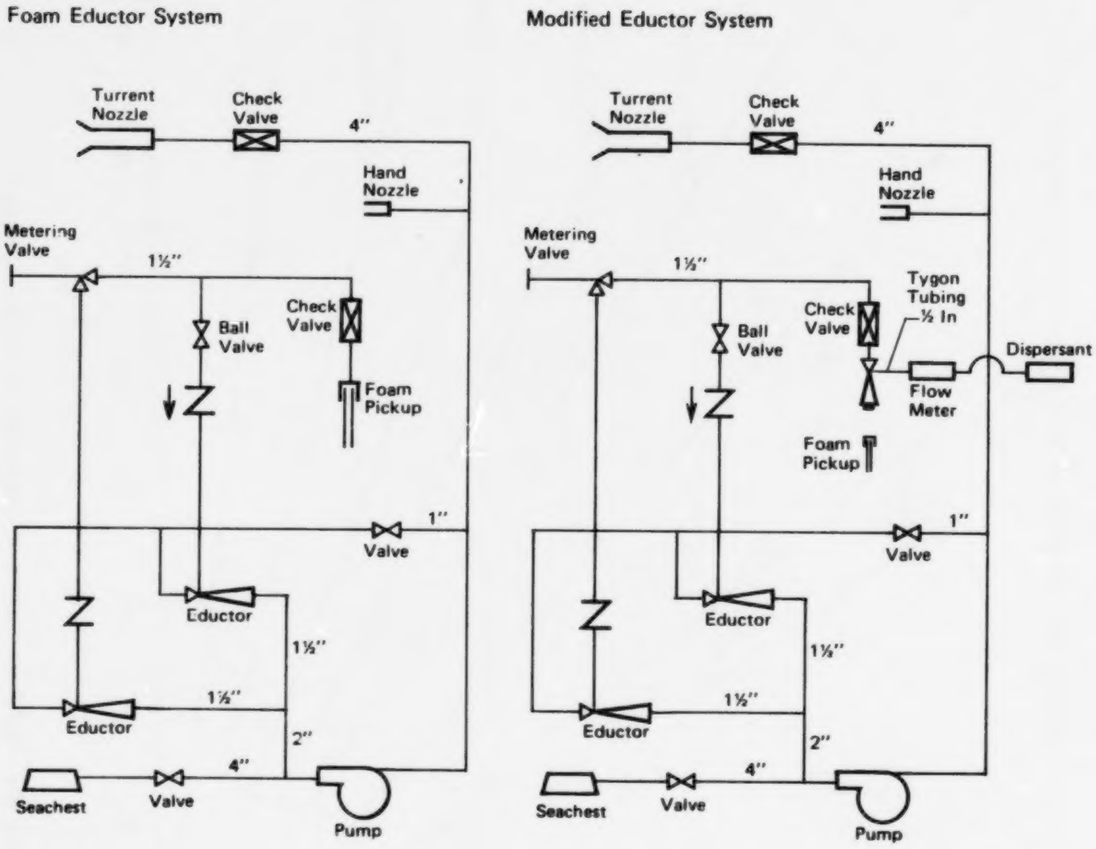
In some cases the discharge and/or pressure can be altered to fall within the desired output specifications. The pump speed may be increased or decreased until the desired performance is obtained. The speed should not be altered too much as this will decrease efficiency and may result in pump and motor damage.

Other methods for adjusting output include: installing gate or pressure compensating flow control valves, enlarging or decreasing nozzle size, or a combination of both. It is generally very difficult to change volume without affecting pressure and vice versa. If pressure is altered significantly, the spray angle of the nozzles and droplet size should be checked.

The spray angles can be checked by observing the spray overlap when operating the system at normal volume and pressure. A 10 to 20 percent spray overlap at the water surface is desired. If there is no overlap, or it is too great, nozzles may be replaced with ones which have the required spray angle. The nozzles should produce coarse (raindrop) size droplets, and never a mist or fog.

If metering or injection pumps are used to introduce the dispersant into solution, the pump setting determines the chemical output of the system. If a standard, low-volume pump is used, it can again be checked and calibrated by installing a flow meter in the line or by holding a graduated container under the discharge port of hose for a known period.

Eductors have adjustments which control the approximate percentage of dispersant in solution. The amount of dispersant introduced into solution is directly related to the quantity of seawater flow. Figure B-6 allows computation of the gallons per minute of dispersant in solution at various eduction rates and discharge volumes. Using this figure the eductor can be set at the percentage that produces the desired amount of dispersant in solution.



Foam Eductor System

Modified Eductor System

Figure B-5. U.S. Coast Guard - foam eductor system.

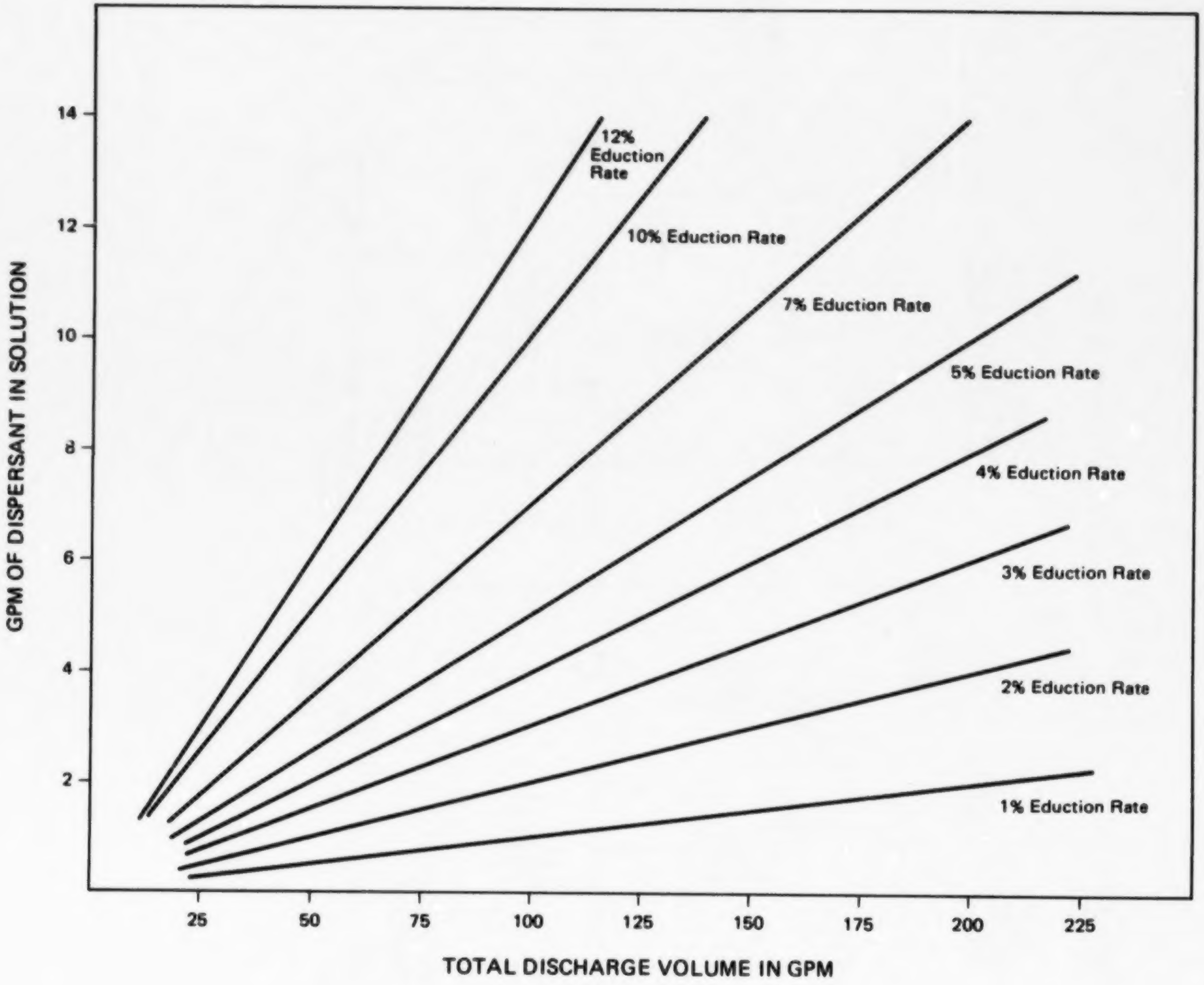


Figure B-6. GPM of dispersant in solution at various eduction rates and discharge volumes.

For absolute accuracy, a flow meter should be installed between the eductor and the dispersant supply.

Single Jet Spray System. Typically, the output volume of this system cannot be calibrated directly by physical measurement. A flow meter inserted inline between the hose and nozzle can monitor total output; if placed between the eductor and the dispersant supply it will monitor dispersant flow. Pressure can be determined by installing a gauge inline between the pump and nozzle.

If the volume is excessive, a bleed line may be installed between the discharge port of the main pump and the eductor or metering pump. A bleed line consists of a "T" fitting placed between two sections of hose with a gate valve coupled at the tail of the fitting. A discharge hose is fitted to the valve and dropped over the side of the vessel. With the pump operating, the gate valve is opened permitting water to flow through the hose and back into the sea. The valve is adjusted slowly until the desired volume and pressure is attained at the spray nozzle.

Procedures for calibrating metering pumps and eductors are similar to those described for spray boom systems.

The swath width for these systems can be visually estimated in the following manner: when all system components operating normally and nozzles set at an arc or manipulated back and forth, the distance the spray reaches on either side of the vessel should be estimated. The sum of these distances and the beam of the vessel will give the approximate swath width.

Dosage Control

Dosage is a function of the output volume or application rate of dispersant, the swath width, and vessel speed. The recommended dosage for a given situation can be determined from Section 405.

Figure B-7 provides a means for determining the vessel speed required to produce a desired dosage. If the dispersant is applied undiluted the procedure is as follows:

1) Plot the calibrated system output volume on the horizontal axis of the large graph.

2) Draw a vertical line to the point of intersection with the desired diagonal dosage line.

3) From that point draw a horizontal line extending through the vessel speed/swath width graph.

4) The intersection of this line with the vessel swath width indicates the relative speed necessary to achieve the desired dosage.

For those systems applying diluting dispersants and using an injection or metering pump, the above procedure is followed with the metering pump output substituted for the total system output.

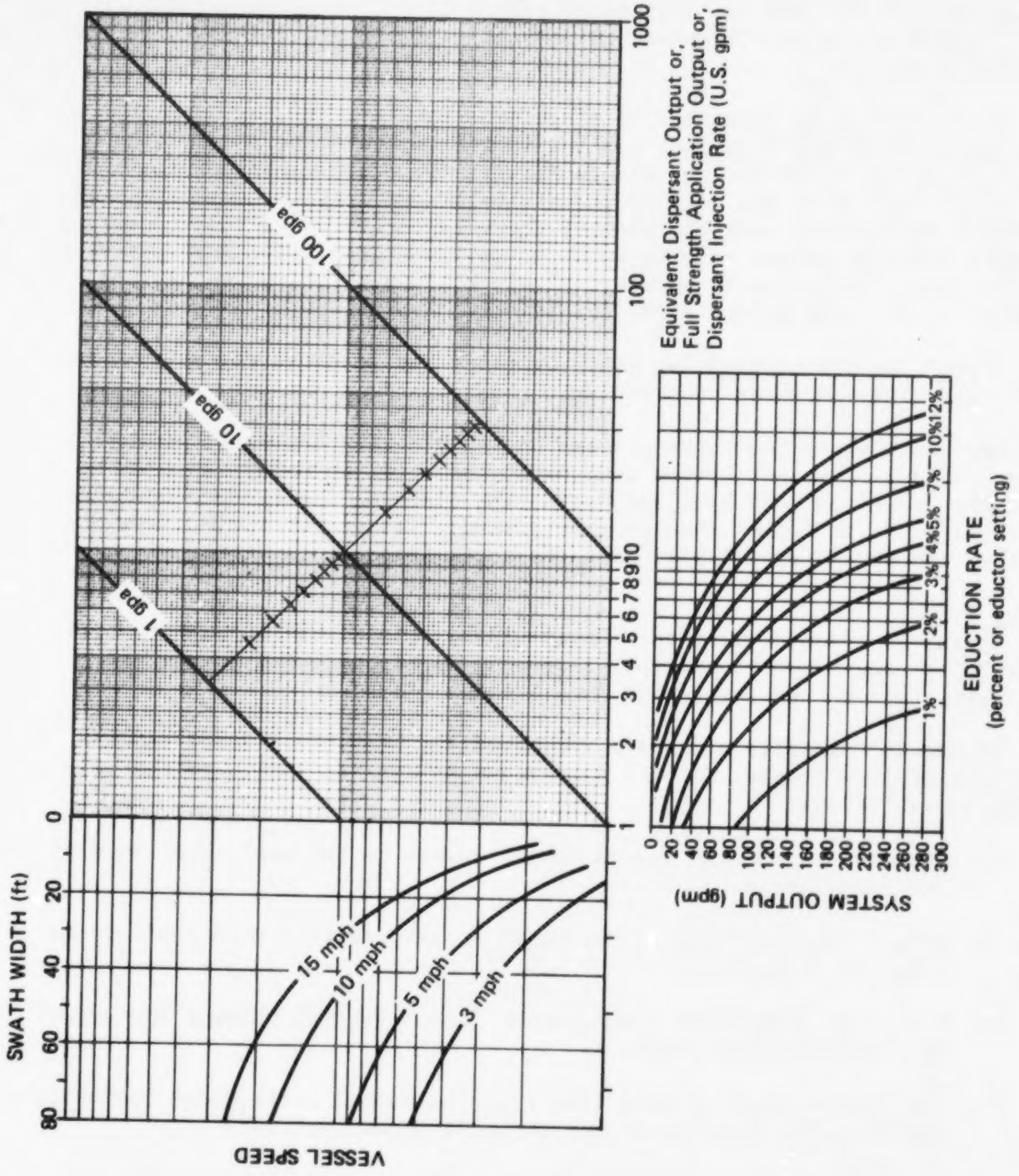


Figure B-7. Vessel speed-dosage rate graph.

If an eductor is used to dilute the dispersant, the following procedure is used:

1) Plot the total system output on the vertical axis of the small, lower graph.

2) Draw a horizontal line to the point of intersection with the proper eduction rate curve.

3) From that point draw a vertical line to the point where it intersects the desired dosage line in the large graph. (The point where the line crosses the horizontal axis of the large graph gives the equivalent dispersant output of the system).

4) Follow steps 3 and 4 described above for undiluted dispersants.

If suitable vessel speeds cannot be achieved, system output must be varied.

Example: It is desired to know the vessel speed required for application of a dispersant at a dosage of five gallons per acre. The system uses an eductor set at two percent and has an output of 100 gpm and a swath width of 40 feet. Using Figure B-7 an approximate vessel speed of five mph is determined as required.

AIRCRAFT APPLICATION SYSTEMS

Aircraft application is normally discussed in terms of helicopter systems, light and medium agricultural systems, and large or heavy aircraft systems. Aircraft should be used only to apply undiluted dispersants. Table B-2 lists typical operating ranges of a few aircraft in each category. General descriptions of each basic application system, calibration procedures, and dosage control are discussed in this section.

Helicopter Spray Systems

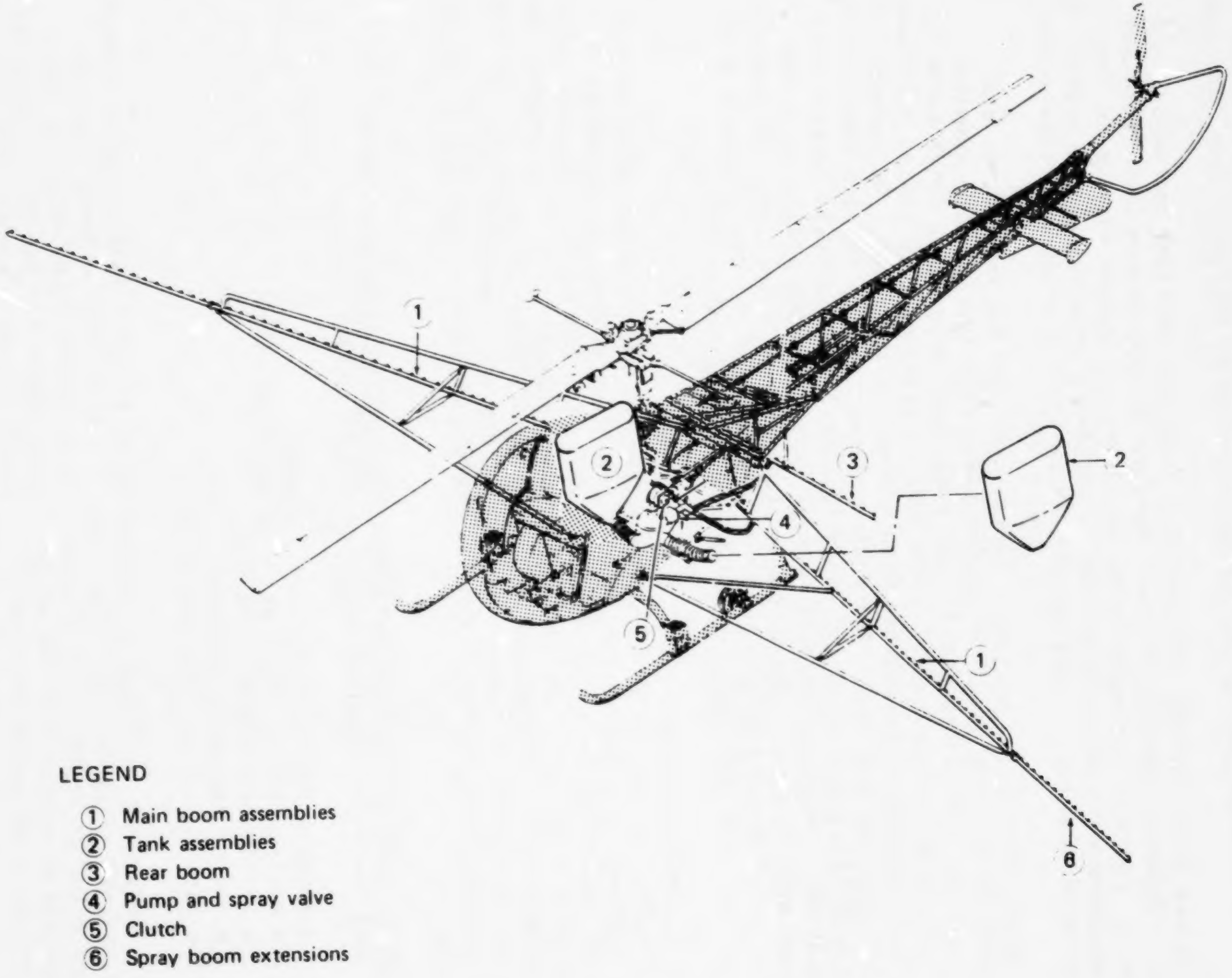
Helicopters prefitted to use agricultural spraying equipment are generally available in most parts of the country. However, agricultural spraying systems usually produce fine mists or fogs and as such are not directly suited to dispersant application. Tests have shown that most can be quickly modifed to produce coarse sprays sufficient for dispersant use by changing nozzles. Two basic types of helicopter systems exist, the on-board (or integral) system and the bucket-type system, which is slung below the aircraft. The systems differ mainly in the method of attachment to the aircraft and in the type of pump power supply.

On-Board Spray Systems. An on-board system consists of a spray pump which supplies chemicals from storage tanks to spray booms fixed below the aircraft. Figure B-8 illustrates a typical system. Depending on the type of helicopter, the spray pump is powered in one of three ways:

TABLE B-2. REPRESENTATIVE AIRCRAFT SPECIFICATIONS

	Cruise Speed (knots)	Cruise Range (naut. miles)	Cruise Endurance (hours)	Useful(a) Payload (pounds)	Liquid(b) Payload Equivalent (gallons)
HELICOPTERS					
Light					
Hughes 300 C	65	195	3	938	111
Continental MKV-A	65	81	1.5(c)	991	118
Medium					
Bell 206 B	122	290	2.3	1,560	186
Hughes 500 D	130	240	2	1,582	188
Heavy					
Bell 205 A-1	106	270	2.4	4,387	522
Sikorsky S-GIN	120	438	3.4	6,464	770
FIXED-WING					
Light					
Piper Pawnee D-235	75(c)	203(c)	2.1(c)	1389	165
Cessna AG wagon	105(c)	256(c)	2.6(c)	1772	211
Medium					
Grumman G-164B	91	N/A	3.5	2,980	355
Emair MA- 1B	105	N/A	2.3	3,648	434
Heavy					
DC-6B	225	1,375	5.5	30,000	3,571
Sup. Constellation	174 (c)	N/A	5.5	N/A	3,500

(a) Maximum sling load for helicopters
(b) Assuming specific gravity of 1.0 and does not include spray system weight
(c) Figures are for working, not cruise



LEGEND

① Main boom assemblies
② Tank assemblies
③ Rear boom
④ Pump and spray valve
⑤ Clutch
⑥ Spray boom extensions

Figure B-8. On-board helicopter spray system.

- directly by power takeoff from the helicopter engine
- hydraulically by an engine-driven pump
- electrically using the aircraft's electrical system. In some systems pump output and pressure can be regulated from the cockpit

Helicopter spray systems are generally installed on light and medium aircraft. Chemical capacity of these systems usually ranges from 50 to 250 gallons. Agricultural spray booms are generally around 40 feet in length and equipped with downward misting or atomizing nozzles. These nozzles must be replaced with hollow-cone spray nozzles which produce rain-size drops.

Bucket-Type Spray Systems. Bucket-type systems are modular and designed to be slung under the helicopter. They consist of a chemical holding tank, gasoline-powered spray pump, and spray booms which are schematically shown in Figure B-9. The pump is operated at a preset speed and constant pressure is maintained with a pressure regulator. On and off cockpit controls are provided. The entire system is slung beneath the helicopter using a quick-release hook and an antiyaw device to maintain correct boom orientation. Chemical capacity of most bucket systems ranges up to 200 gallons, with systems of up to 600 gallons available for large helicopters. Similar to on-board systems, bucket-type spray systems are generally supplied with agricultural type nozzles which must be replaced as before.

Fixed-Wing Spray Systems

Fixed-wing aircraft are routinely used for agricultural spraying and can treat terrestrial areas ranging from a few acres to tens of thousands of acres in relatively short periods of time. As in helicopter systems, modifications are generally restricted to nozzle changes. The most common type of equipment are specially modified light agricultural spraying aircraft and converted multi-engine piston-powered military and commercial aircraft. Fixed-wing aircraft generally require the use of spotter aircraft to direct spraying.

Light to Medium Agricultural Aircraft Spraying Systems. These aircraft have the following ranges of operational capabilities:

- working speed: less than 110 knots
- working range: less than 500 nautical miles
- working endurance: 2-4 hours
- useful payload: 1000-2000 pounds
- tank capacity: 100-500 gallons

The dispersant solution is carried in an integral tank, usually forward of the cockpit or in external wing tanks. A pump located below the tank delivers solution to the distribution or boom system attached either below the fuselage or directly to the wings. Spray pumps are generally mechanically driven by an air-driven propellor (which provides a pump rate proportional to air speed) (Figure B-10) or by a hydraulic system operated off the aircraft engine (Figure B-11). For dispersant modification, the aircraft

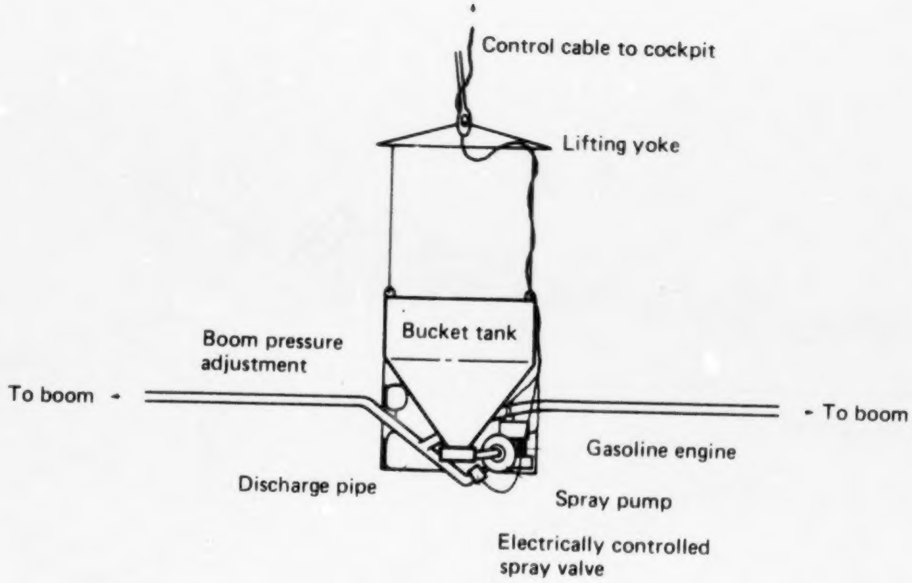


Figure B-9. Bucket-type helicopter spray system.

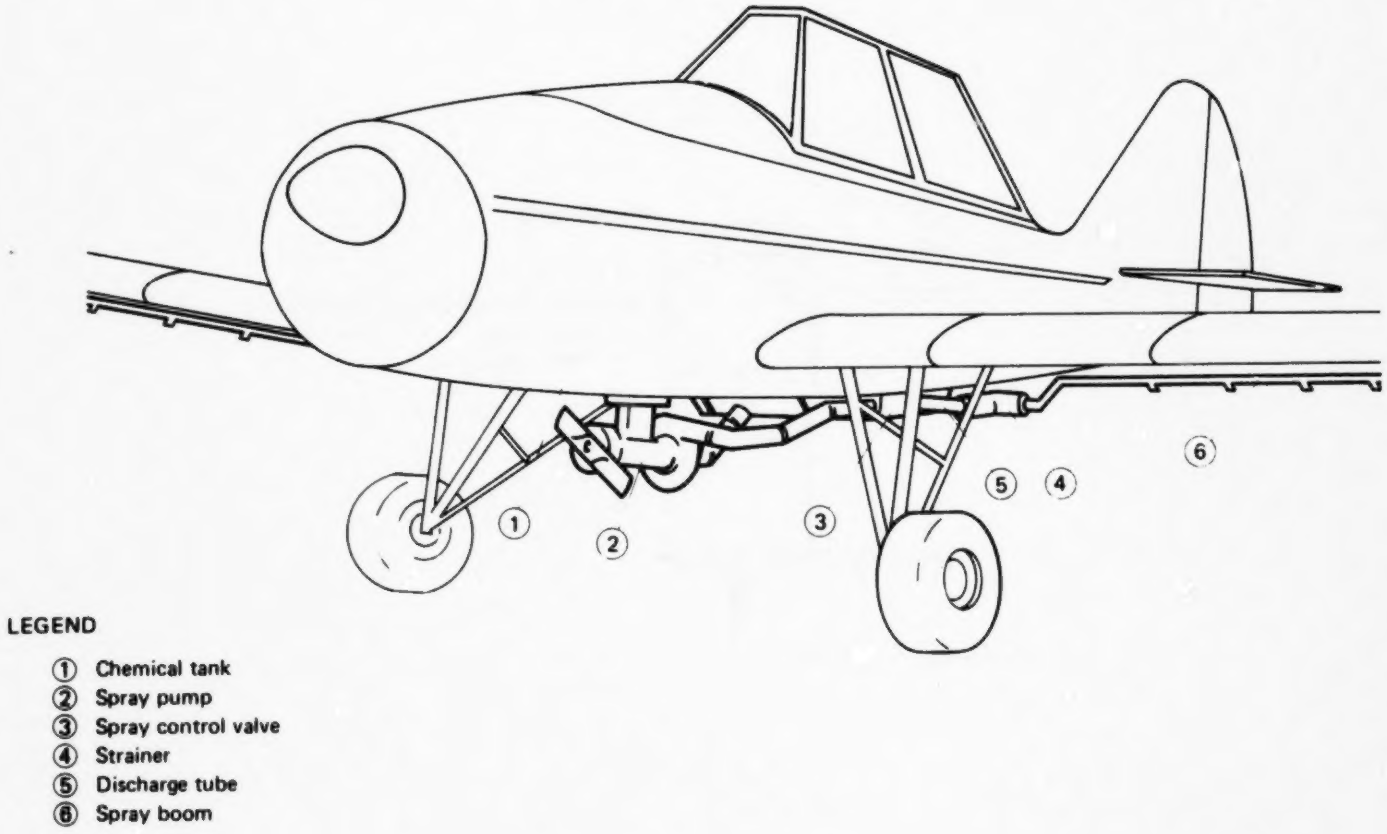


Figure B-10. Light agricultural spray system wind driven pump.

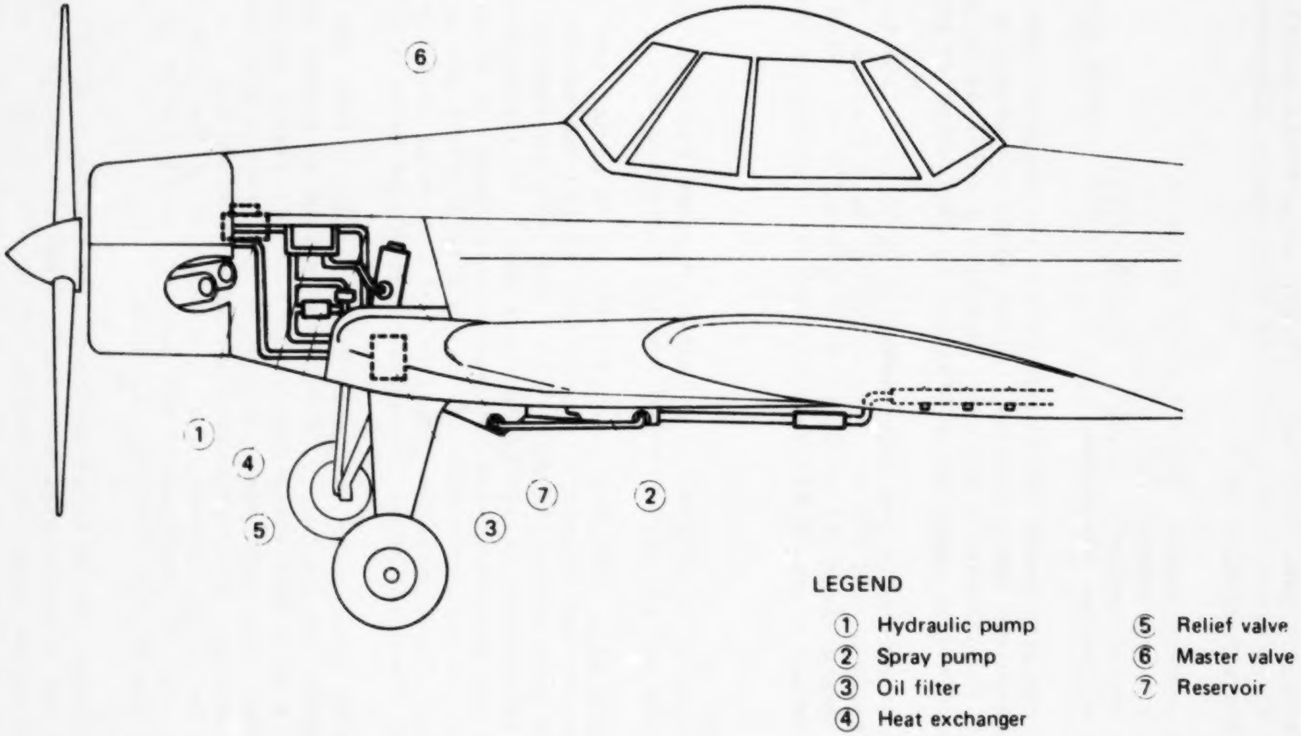


Figure B-11. Light agricultural spray system: hydraulic pump.

must be equipped with spray booms which have replaceable nozzles, and preferably a boom width approaching the aircraft's wingspan.

Heavy Aircraft Spraying Systems. A variety of heavy commercial and military aircraft have been converted for large-scale aerial spraying applications. These aircraft are typically multi-engine piston-powered machines. Aircraft characteristics include:

- working speed: 100-250 miles per hour
- working range: 500+ miles
- useful payload: 18,000 - 30,000 pounds
- equivalent dispersant capacity: 2,500 - 4,000 gallons

High capacity pumps are necessary for the outputs required by these large, high-volume spray systems. These pumps are generally driven by one or more of the aircraft's engines. Dispersant solution is pumped from tanks within the craft to spray booms attached to the bottom or top of the wings.

System components are interconnected by piping which is valved for turning the system on and off and recirculating the solutions. The valves are usually operated from the cockpit and electrically activated. As with many types of aerial spraying systems, most existing equipment will require modification.

Calibration

Calibration of aircraft application systems includes consideration of droplet size and the output volume or application rate.

Droplet Size. Droplet size is critical in aerial application. Very small droplets may evaporate before reaching the sea surface. Small droplets are also highly subject to wind drift, complicating control of coverage and dosage. Excessively large droplets may result in inefficient surface distribution of the dispersant and may penetrate through the slick. Test programs suggest aerial application is effective when droplets are in the 250 to 1000 micron size range, with the larger end of the range probably being most effective. Manufacturers' recommendations should be followed when available.

Droplet size can be estimated by performing a test run over land at the desired speed and altitude, and with the system at normal operation. Nonabsorbent 4 to 5 inch square cards are randomly placed perpendicular to the flight path. The cards are collected after a single pass and the droplet splats measured. An average size or range of sizes can then be determined. It should be noted, however, that the diameter of the splat on the card will be larger than the diameter of the droplet itself due to the flattening effect of the droplet striking the card.

The dosage can be field calibrated as mentioned above. The drops on the cards are not only measured but counted, and the results averaged. Dosage can be estimated using the formula, $D = Nr^3 (4.5 \times 10^{-8})$, where D = gallons per acre, N = number of drops per square centimeter, and r = droplet radius in microns.

Nozzle Selection. Most agricultural spraying systems available for application of dispersants are supplied with atomizing or misting nozzles. These nozzles must be replaced with nozzles which produce a coarse spray and usually a larger output. Test experience indicates that hollow cone nozzles fitted with cores which impart rotation to the existing flow, produce acceptable sprays. If the pumping system is adjustable, the pump rate may be modified until acceptable drop sizes are obtained. To increase drop size, alternate nozzles may be blocked off, permitting use of fewer, larger bore nozzles.

Tests also suggest that orienting nozzles directly aft increases both droplet size and swath width.

At speeds above 120 mph, i.e., heavy aircraft, nozzles may not be required. Wind shear is sufficient to create uniform spray formation and satisfactory droplet size. Tests using pipe nipples (facing aft) instead of nozzles produced acceptable (although less regular) spray patterns of satisfactory drop diameter (toward the large end of the desired range).

Output Volume. Ground calibration of the output volume is done the same way as for vessels. The pumping system is operated at working speed (with water) with a graduated container held under a nozzle for a given time to collect the discharge. The quantity collected is multiplied by the number of nozzles to give the output in gallons per minute (gpm). This procedure should be repeated at several nozzles along the boom and the results averaged.

Systems using wind-driven pumps, however, cannot be physically calibrated on the ground. These pumps must be calibrated by calculation at a given airspeed, using the pump performance curves supplied by the manufacturer or by test application. A pump output at a midrange airspeed should be used for calculation.

Figure B-12 can be used to estimate required pump capacities at various air speeds and swath widths. To estimate pump requirements compare the anticipated range of operating speeds and estimated effective swath widths (ground width) with the desired dosage. The right hand column can then be used to estimate pump requirements.

To use this nomogram, draw a line from the calculated ground speed through the effective swath width to find a coverage rate. From that point draw a line through the desired dosage rate to the system output column. The point of intersection gives the required output.

Dosage

Dosage is a function of pump capacity and pressure, effective swath width, and ground speed. It is recommended that system output be held constant and calibrated as described above. Application should also be held constant (altitudes of 25 to 50 feet have been shown to be effective). Dosage can then be controlled by varying airspeed. In cases where it is not practical to design or modify a system to deliver a determined dosage, multiple applications may be necessary to achieve the desired effect.

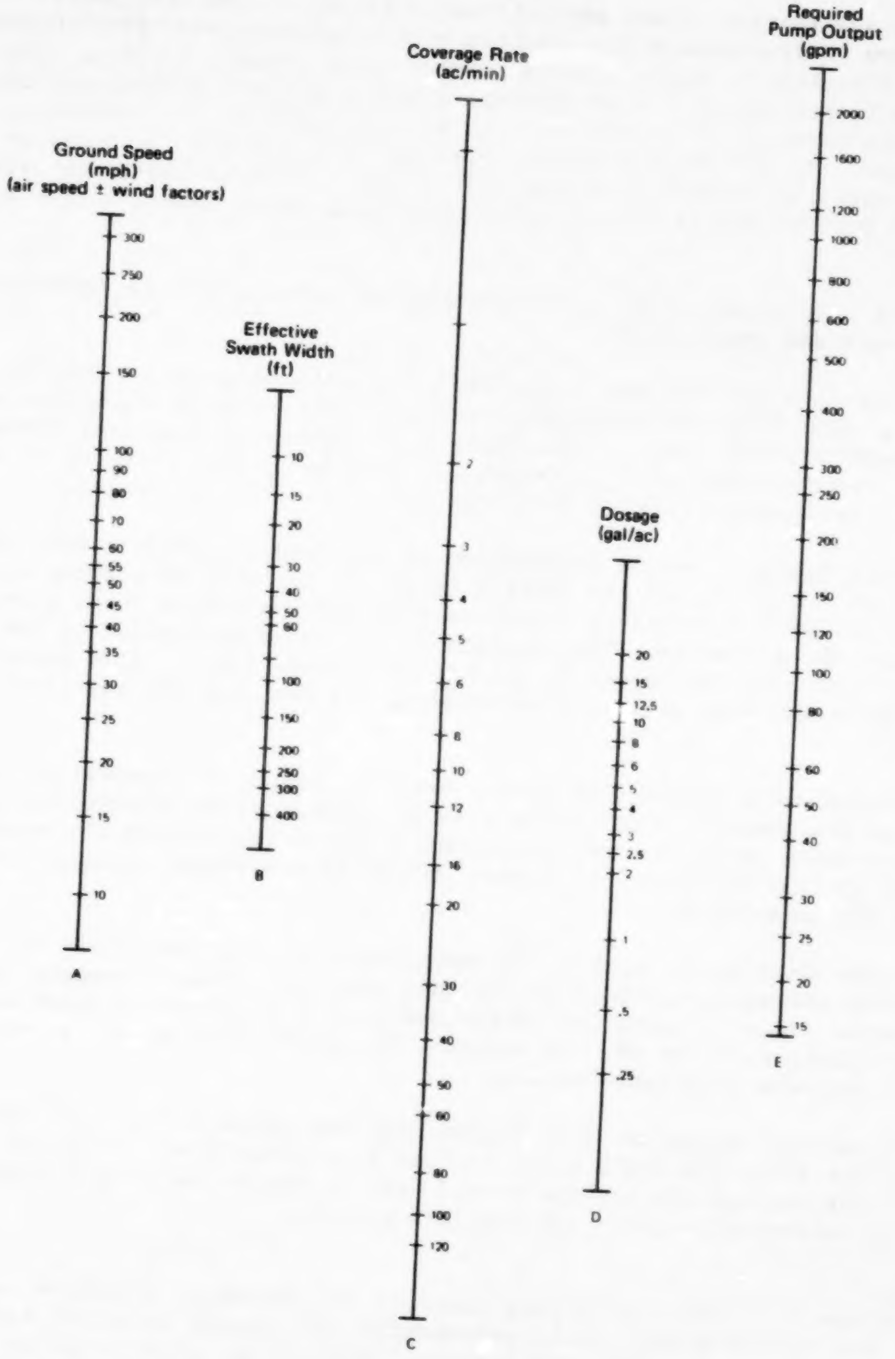


Figure B-12. Pump output calculation nomogram.

The application or air speed required to give a specific dosage can be determined using Figure B-12 if system output and effective swath width are known. (The effective swath width is greater than the boom width, typically by 1.5 to 2 times. Determination of its actual width requires field measurement).

Example: A spray system has been calibrated as delivering 40 gpm; the desired application rate is 10 gallons per acre. The effective swath width has been determined to be 60 feet. A line is drawn connecting these points and intersecting column A, where a ground speed of 35 mph is obtained. Weather reports indicate a headwind of 5 mph in the desired direction. As such, the required application airspeed is 40 mph.

Field calculation of dosage can be made using the procedure for calibration of droplet size.

APPENDIX C

SHORELINE APPLICATION DISPERSANT SYSTEMS

DISPERSANT EQUIPMENT AND PROCEDURES

The type of equipment used to apply dispersants to shorelines varies with the type of dispersant, the type and amount of oil contamination, and the application technique selected. The following discussion identifies equipment suitable for application of dispersant types specified in Section 504.

Hydrocarbon Base Dispersants

Areas with limited contamination can usually be treated with a backpack or hand-held garden sprayer. Hand-held sprayer lances are generally fitted with a single, wide-angle nozzle which produces a coarse spray. Larger areas require a stationary or mobile high-volume pump with dispersant tank and capable of serving one or more spray lances with long hoses.

Hydrocarbon base dispersants are generally required to treat viscous or weathered oil. They dissolve or soften coatings which permits their removal by flushing, high-pressure blasting, or steaming. In some cases, natural wave action may be sufficient. Only light applications of dispersant should be made, together with a suitable reaction period before flushing or additional dosage is attempted. The amount of time should be determined on a case-by-case experimentation. For thick or heavily weathered deposits, repeated application may be required.

Water Base Dispersants

Water base dispersants can be applied by several different methods. The extent of contamination, the type of substrate, the availability of equipment, and the desired effect determine the proper method. Water base dispersants can be used to (1) directly assist in removal of oil, or (2) prevent the reformation of slicks from loosened material. Table C-1 lists different application methods for three types of oil contamination.

Generally, small contaminated areas can usually be treated with a backpack or hand-held garden sprayer containing a premixed solution of dispersant and seawater. After a suitable reaction period, the treated area may require supplementary flushing. Larger areas are more efficiently treated with spray lances or fire hoses. If the oil coating is viscous, water base dispersant can be injected into a high pressure water washing stream (hydroblaster).

Mobile agricultural spraying equipment can be used for extensively contaminated flat-lying areas, if eductors or injection pumps are incorporated

TABLE C-1. WATER BASE DISPERSANT APPLICATION METHODS

Extent and Location of Oil Contamination	Application Method	Mixing Method
small area (vertical or horizontal	backpack sprayers	premixed
vertical area	hand-held lances and pumps	premixed
	injection into hydroblaster	induction
	fire hose, fire pump and eductor	eduction
large horizontal area	mobile agricultural spraying system	premixed
	aerial	undiluted
	fire hose, fire pump, eductor on vehicle with salt water tank	educted

into the system and an adequate seawater storage tank is fitted on board or towed behind the spraying equipment. Fire pumps, fire hoses and eductors can also be placed on a vehicle with a salt water storage tank to apply dispersants over a large area. Effectiveness may be increased by discing the contaminated area prior to treatment or pushing treated material into the surf thereby facilitating natural cleaning. Shoreline trafficability or lack of access may preclude use of vehicles on a beach.

DOSAGE CONTROL

Control of the application rate on shorelines can be extremely difficult and is important when dispersant and removed oil cannot be recovered. Although most individual application systems can be calibrated and regulated, their operators cannot. The tendency to overtreat areas of higher contamination may be difficult to avoid.

The potential for overdosage is greatest with hydrocarbon base dispersants. With water base dispersants, dosage can be controlled to some degree by limiting the initial concentration. When very low concentrations are used to prevent removed oil droplets from reforming, overdosage should not be a major problem. Field instruction and supervision of application personnel will reduce the potential for overdosage.

Unless oily runoff is collected, shoreline treatment should be limited to periods just prior to high tide, when rapid dilution of treating agent and removed material will be greatest.

APPENDIX D

APPLICATION OF SURFACE COLLECTING AGENTS

APPLICATION PROCEDURES

Manual Application

Manual application of surface collecting agents (SCA) can be done using commercial backpack sprayers or hand-held garden sprayers with hand operated pumps and the nozzle of the spraying wand set to deliver a stream or coarse spray. If spray equipment is unavailable, squirt bottles or other containers can be used, provided the application of excessive quantities of SCA is avoided. In any case, SCA should be applied as close to the water surface as possible to avoid wind losses. SCA should only be applied between the oil and the area to be protected, or around the perimeter of the oil.

Vessel Application. For moderate to large spills occurring in open water, application of SCA from vessels of opportunity can be done by modifying low output vessel dispersant spray equipment. A single dispersant spray boom should be mounted in a position toward the rear of the vessel so that the SCA are sprayed on the area least affected by the bow wake and propeller wash. The inboard nozzles on the spray boom should be shut off or plugged, leaving only the outboard nozzle open for application. The outboard nozzle will probably have to be modified to make a stream or coarse narrow spray pattern. The pumping system may also require modification or a valve placed in the line to provide a lower flow rate. Vessel speed must be slow enough to prevent turbulent mixing of the SCA by the vessel wake.

Aerial Application. Both helicopters and fixed wing aircraft can be used to apply SCA. Aerial agricultural spraying systems which are modified for dispersant spraying can also be adapted for collecting agent application. Modification of the spraying systems primarily involves changing or plugging the nozzles to make a single stream or coarse narrow spray. The outboard nozzles on the aerial spray booms should be shut off or plugged, leaving one or two inboard nozzles in operation. If a coarse spray is required, the nozzles can simply be replaced with those producing the desired spray configuration. For applications requiring a fine stream, the nozzles again can be interchanged. If the proper nozzles are not available, several other modifications can be made. In some cases the disc or core of the nozzles can be removed, producing a single stream discharge. If not, a short length of rubber hose can be fitted around the nozzle, resulting in the spray hitting the inside of the hose and subsequently running out the end as either a single stream or a stream of large drops. As a last resort, the nozzles can be removed altogether, allowing the agent to be pumped directly out the resulting holes.

For helicopters using the bucket-type application system, there is a bucket available that does not use spray booms, but rather a single discharge nozzle located directly under the storage container or bucket. The nozzle can be modified as described earlier to produce a coarse spray or fine stream. Bucket-type systems are usually best suited for applying SCA to moderate size spills as they can be fitted to most helicopters with a minimum (if any) number of modifications and do not require FAA approval.

When SCA are applied from the air, the aircraft should be as low as possible and move as slowly as is safe to avoid excessive wind shear and dispersion of the agent over a large area. Helicopters are best suited for this method of application.

Other Application. In cases of oil seepage, persistent leaks, or small continous spills in an area having unidirectional currents, a drip pot may be used to apply SCA to the water surface in metered amounts over a long period of time. A drip pot is a drum or container of the agent fitted with a drip-type metering device. It is usually placed on the deck of a stationary ship, or structure downstream from the source of contamination. The flow should be adjusted to the stream or current velocity and in quantities that will conform to approved application rates.

DOSAGE CONTROL

Dosage control of SCA is simple, provided the output of the system is known. Output can be determined by operating the equipment at the normal speed or setting, and holding a graduated container under the discharge outlet or nozzle for one minute. The amount collected is the system output given in volume per minute. If multiple outlets are used the amount is multiplied by the number of outlets.

Once the outlet is known, the dosage can be accurately controlled by varying the speed at which it is applied. The graph in Figure D-1 can be used to determine the required application speed given the system output and desired dosage.

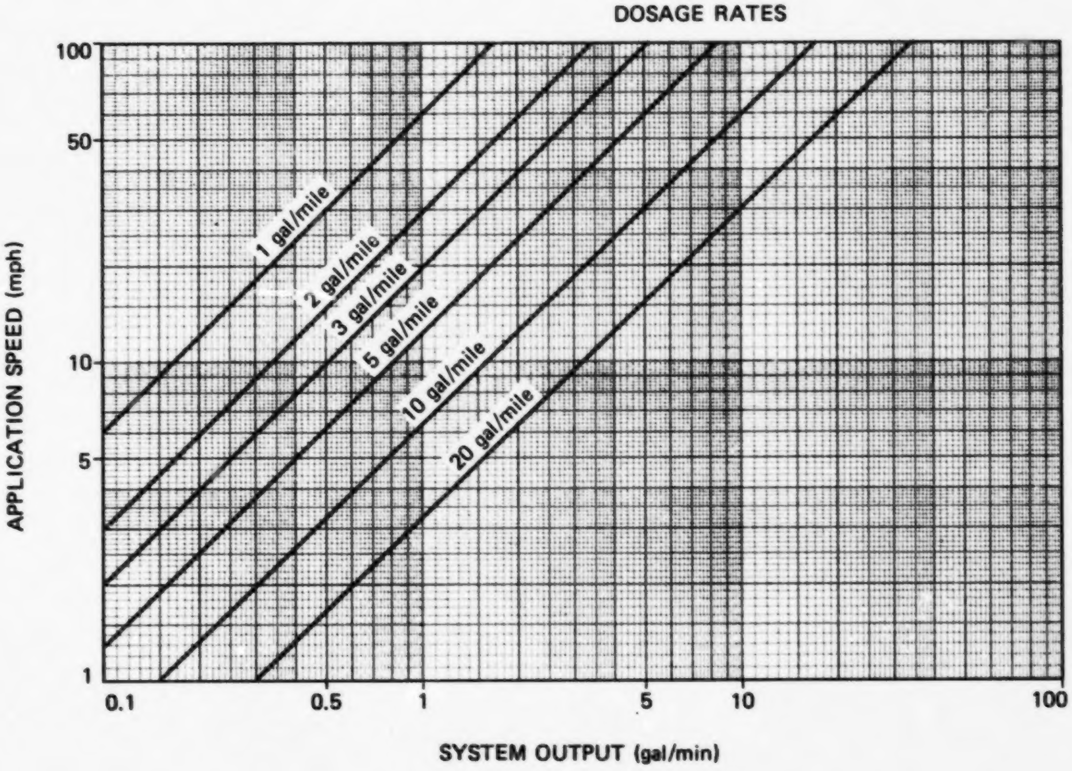


Figure D-1. Surface collecting agent application speed guide.

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